QUARTERLY TECHNICAL PROGRESS REPORT

July, August, September 1966

DEPARTMENT OF COMPUTER SCIENCE · UNIVERSITY OF ILLINOIS · URBANA, ILLINOIS

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1. CIRCUIT RESEARCH PROGRAM

(Supported in part by the Office of Naval Research under Contract Nonr-1834(15).)

Summary

Research in the area of Random Sequence Coding is being continued by Chushin Afuso, who reports on multiplier and divider units using previously explained techniques.

Larry Wallman describes some circuit refinements for Phastor---the analog memory.

In the Electro-Optical work Tak Katoh presents the construction and theory of operation of a matrix type of electroluminescent panel and indicates a control system for driving it.

1.1 Random Sequence Coding

Experimental units of a multiplier and a divider have been tested. For the multiplier a static accuracy of 1% is obtained quite easily over a 5-volt full scale, and 3% is obtained for the divider.

1.1.1 Multiplier

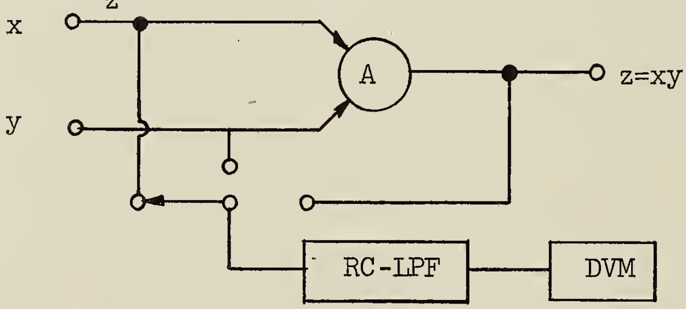
A simple diode AND gate and a wave-shaping circuit are employed to perform multiplication.

The error due to the statistical fluctuation was discussed in the last progress report. To eliminate this, the experiment was done with a very long averaging time, and the accuracy obtained under these circumstances is termed the static accuracy.

Considering the actual situation where pulse heights are not exactly equal for all sequences, x, y and z, the relation between the inputs and the output is:

$$\frac{V_z}{V_{0z}} = \frac{V_x}{V_{0x}} \cdot \frac{V_y}{V_{0y}} \qquad (1)$$

where V_x, V_y, and V_z are the average voltages of the x, y, and z



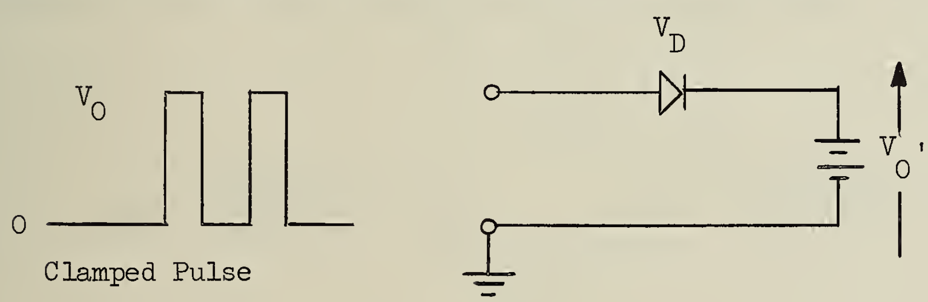
RC-LPF: RC low pass filter with 1 sec. time constant
DVM: Digital voltmeter
Figure 1. Block Diagram for Multiplier Test.

sequences, and V_{0x}, V_{0y}, and V_{0z} are their pulse heights, respectively. If (1) is rewritten,

$$V_z = \left(\frac{V_{0z}}{V_{0x}\ V_{0y}}\right) V_x V_y \qquad (2)$$

this is the usual formula for an analog multiplier with the scale factor $V_{0z}/(V_{0x}V_{0y})$. For convenience, it is desired to make the pulse heights of all sequences equal. In practice this is achieved to some extent by clamping the pulse sequences with a common clamping voltage through the same types of clamping diode. Therefore, practically $V_{0x}=V_{0y}=V_{0z}=V_0$ within the error tolerance of diode characteristics.

Since the scale factor $V_{0z}/(V_{0x}V_{0y}) \simeq 1/V_0$ determines the accuracy of the multiplier, measurement of the pulse height, V_0, is significant. But it is difficult to measure the pulse height direct with high accuracy, say 1%. In this experiment an indirect measurement was carried out by utilizing (2). The measurements of V_x, V_y, and V_z, which are DC may be done with a digital voltmeter with 0.1% accuracy. For example, for the pulse height of 10 volts, $V_x=V_y=5$ volts and therefore $V_z=2.5$ volts, the accuracy of the pulse height measurement is about 1%, including the error due to clamping diodes. Therefore the static accuracy of the multiplier in this case is 1% of the full scale of 5 volts.



$V_0 = V_0' + V_D$

V_0: Clamped pulse height

V_0': Clamping voltage

V_D: Diode forward drop

Figure 2. Relation for Clamping.

Figure 2 shows the trivial arrangement for clamping. It is obvious that a higher pulse height is desirable so that the effect of the diode is made small.

Another possible source of error in an extreme case would be a finite switching time of the AND gate. Namely, if the overlapping duration of the two input pulses is so short that the AND gate cannot

react, this would produce a negative error at the output of the multiplier. Although this effect was not observed in this experiment, it may be expected when the switching time is long relative to the pulse width.

1.1.2 Divider

The divider consists of a multiplier and an additional random pulse generator with a differential amplifier. Thus an additional error may be produced at the differential amplifier because of its finite offset voltage.

A possible, perhaps the simplest, circuit for the differential amplifier which controls the discrimination level of the quotient generator is shown in Figure 3.

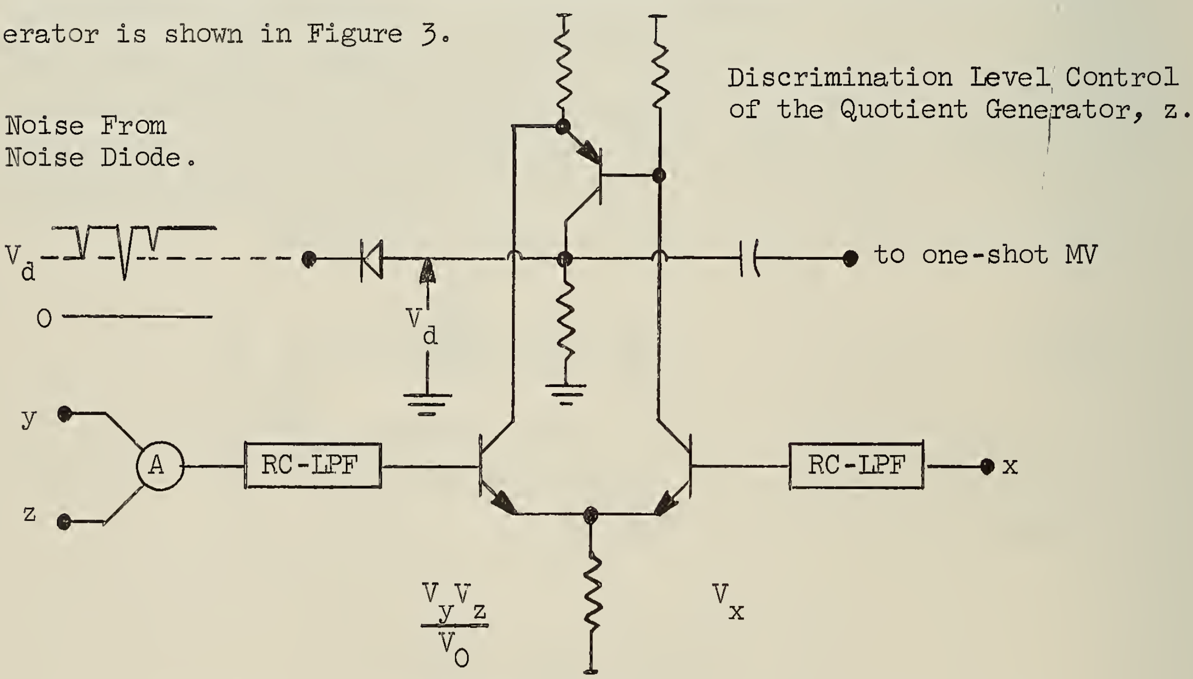


Figure 3. A Differential Amplifier Which Controls the Quotient Generator.

The offset voltage in this case is determined by the difference between the emitter-base drop of the two transistors and is of the order of several hundredths of volt. This yields an additional 2% error for a full scale of 5 volts. Thus the static accuracy of the divider is about 3% of the 5-volt full scale.

So far we have been concerned with the static accuracy. In order to find the dynamic accuracy we simply add the statistical fluct-

uation corresponding to a given average-taking time.

1.1.3 Future Problems

In order for the random pulse sequence system to be accepted as an analog computing system, the analog quantities must be converted into the corresponding random pulse sequences. An analog-to-random pulse converter is being developed.

The random pulse sequence, which we have considered so far, has a continuous time scale, namely, a pulse may occur at any time. A system in which the time scale is quantized and controlled by a central clock has certain advantages. This will be discussed in the next report.

Chushin Afuso

1.2 <u>Phastor</u>

In the last quarterly report the basic operation of the Phastor was explained. The circuits have been built and tested and work fairly well. However, the reliability and stability were found to be too low. The period of the delay unit (monostable multivibrator with gated feedback) is very sensitive to temperature. This has been compensated for by adding a 5K trimming potentiometer in place of the 3K ohm resistor to the +25V supply, as shown in Figure 1. The ramp generator was found to be unstable, that is, it did not always start after the correct number of clock pulses. This caused the stored time delay to vary in relation to the main ramp. Circuits are being designed which will lock the ramp to the clock. The ramp generator will not be of the feedback type, as first tried, but rather a ramp which will be forced to be a required number of clock pulses in length. This should eliminate some of the synchronization and stability problems.

Larry Wallman

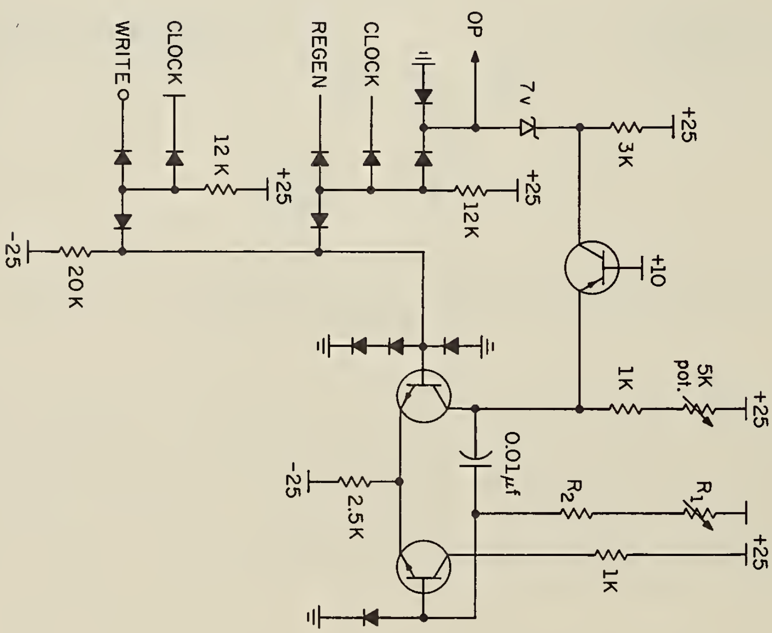
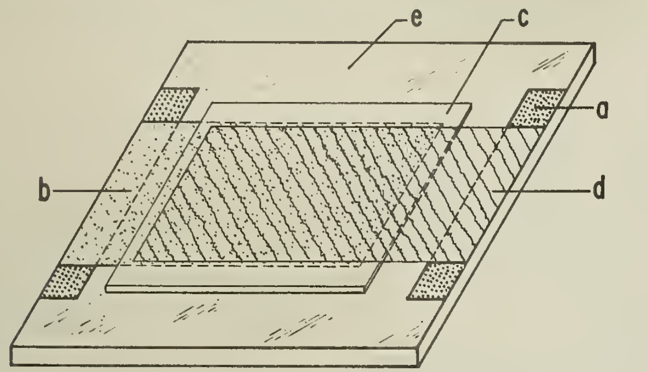


Figure 1. Monostable Multivibrator Storage Unit.

1.3 Electroluminescent Panel

1.3.1 Construction and Operation

A typical electroluminescent cell is shown in Figure 1. When an alternating voltage is applied to the electrodes, light is emitted,

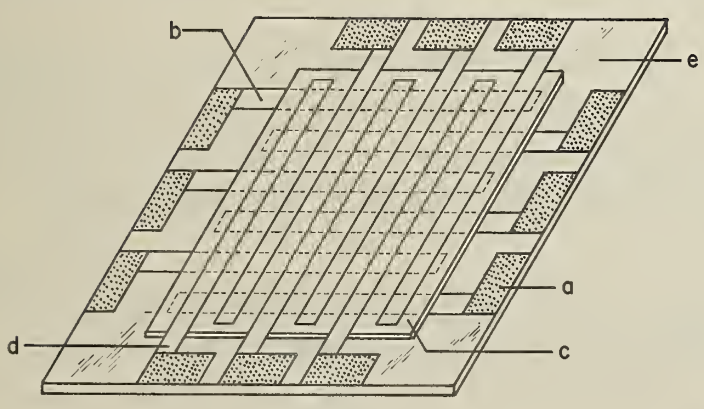


a) Silver contact
b) Transparent gold on bismuth oxide
c) Phosphor layer
d) Copper
e) Glass

Figure 1. Electroluminescent Cell.

and it emerges through the transparent bismuth-oxide/gold layer. Contact is made to the electrodes by soldering directly to silver strips baked into the glass substrate. The phosphor layer is actually two layers. The first is a suspension of zinc-sulphide phosphor in nitrocellulose, and on top of this is a layer consisting of barium titanate in a resin binder.

To make a matrix of cells, the single electrodes are replaced by narrow conducting strips, as shown in Figure 2. The strips are pro-



a) Silver contact 'flag'
b) Transparent gold strips
c) Phosphor layer
d) Copper strips
e) Glass

Figure 2. Electricluminescent Matrix.

duced by a photo-etching process, and each has a silver contact 'flag'.

As the amplitude of the voltage pulse is varied, the variation in the maximum amplitude of the light pulse can be expressed approximately by a relationship of the form

$$B = A \exp\left(-b/\sqrt{V}\right) \tag{1}$$

where A and b are parameters which depend on the phosphor, the cell construction and the experimental conditions, and V is the amplitude of the excitation voltage pulse.

1.3.2 Discrimination Ratio

Let the excitation voltage pulses, as shown in Figure 3, be applied to the conductors of the matrix. Thus the selected-row conductor receives a pulse which rises from 0 to $+V/2$ with respect to ground, and the pulse on the selected column goes from 0 to $-V/2$ with respect to ground.

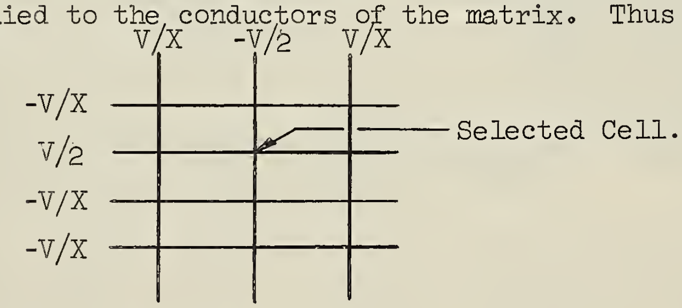


Figure 3. Cell Selection.

All the non-selected row conductors are connected together and receive a pulse which goes from 0 to $-V/X$, and the non-selected columns one which goes from 0 to V/X. Therefore the selected cell has a pulse of amplitude V. The $2(n-1)$ cells along the selected row and column have pulses of $(V/2-V/X)$. The remaining $(n-1)^2$ cells have pulses of $(2V/X)$. The special cases are when

1) $X \to \infty$, i.e., the non-selected conductors are all grounded. There are then $2(n-1)$ unselected cells with pulses of amplitude $V/2$, and $(n-1)^2$ have no voltage across them.

2) $X \to 6$, when all (n^2-1) unselected cells have pulses of amplitude $V/3$.

Each cell will emit a light pulse which has a maximum intensity given by equation (1). If V_w is the 'wanted' signal, i.e., the output from the photo-multiplier resulting from the light emitted by a selected '1',

$$V_w = A'\exp\left(-b/\sqrt{V}\right) \tag{2}$$

The 'unwanted' signal, i.e., the output which would result from all (n^2-1) unselected '1's when a '0' is selected is

$$V_u = 2(n-1)A'\exp\left(-\frac{b}{\sqrt{V}}\sqrt{\frac{2X}{X-2}}\right) + (n-1)^2 A'\exp\left(-\frac{b}{\sqrt{V}}\sqrt{\frac{X}{2}}\right) \tag{3}$$

Thus, the ratio of wanted to unwanted signals is

$$\frac{V_w}{V_u} = \frac{1}{2(n-1)\exp\left[-\frac{b}{\sqrt{V}}\left(\sqrt{\frac{2X}{X-2}}-1\right)\right] + (n-1)^2\exp\left[-\frac{b}{\sqrt{V}}\left(\sqrt{\frac{X}{2}}-1\right)\right]} \tag{4}$$

Using equation (4) curves of V_w/V_u as a function of X drawn for $b/\sqrt{V}$ varying from +0.5 to +4.5, with n=28 are shown in Figure 4. Observed values of $b/\sqrt{V}$ ranged from about 40 to 45 for n=28 which gives a usable value of V_w/V_u. The optimum value of X is close to 6.

1.3.3 Control System

Suppose the cells with coordinates (1,1) and (2,2) are selected. It is necessary to insure that (1,2) and (2,1) are not also lit. To solve this problem either columns or rows are controlled by a cyclic counter. The system is shown in Figure 5.

Tak Katoh

References:

Kilburn, T., Hoffman, G. R., and Hayes, R. E.: 'An Accurate Electroluminescent Graphical-Output Unit for a Digital Computer', Proceedings I.E.E., Paper No. 2441 M, October, 1957 (105B, p. 136).

Hoffman, G. R., Smith, D. H., and Jeffreys, D. C.: 'High-speed Light Output Signals from Electroluminescent Storage System', Proceedings I.E.E., Paper No. 3217 M, Feb. 1960 (108B, p. 599).

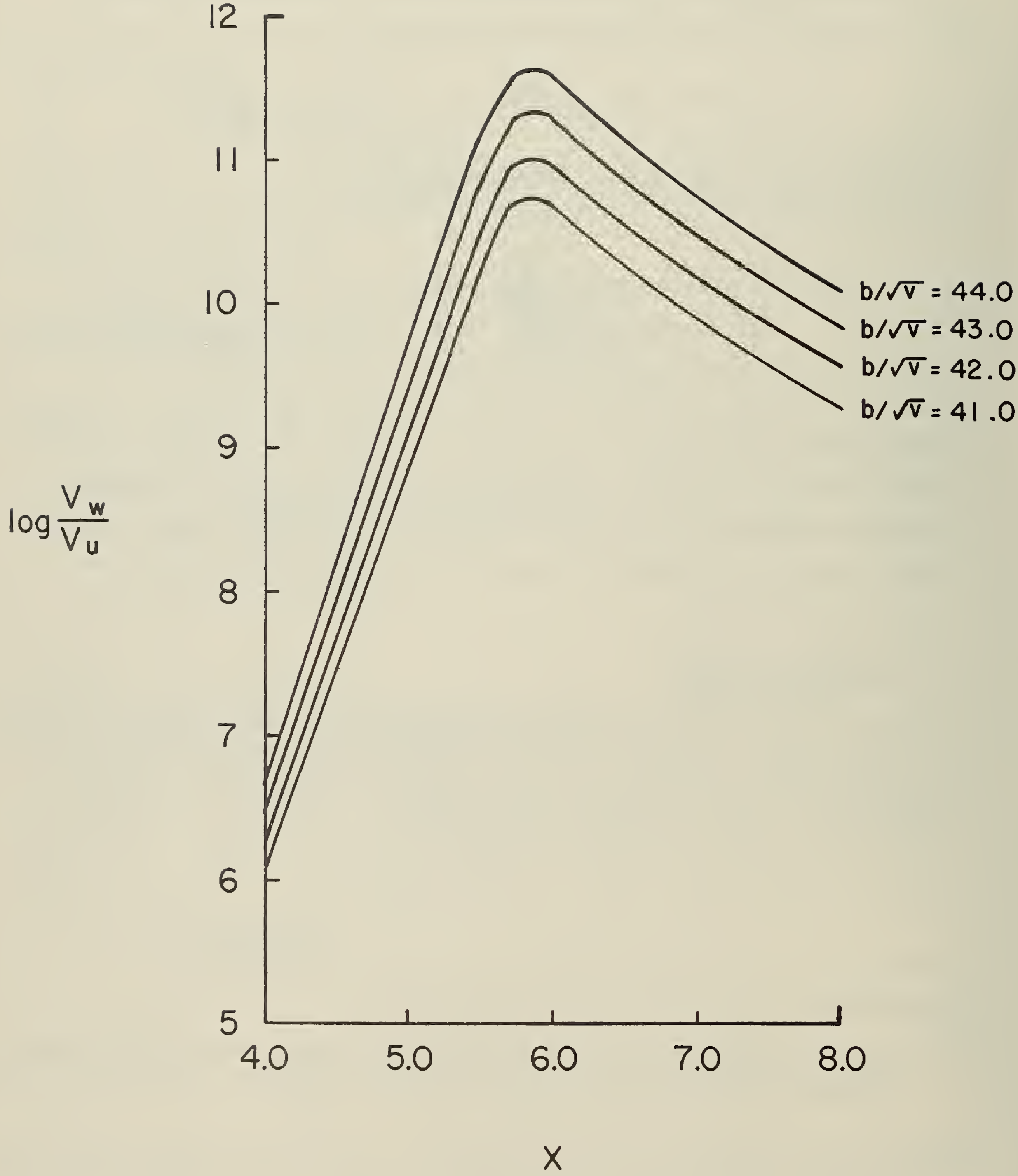


Figure 4. Discrimination Ratio for 28x28 Matrix.

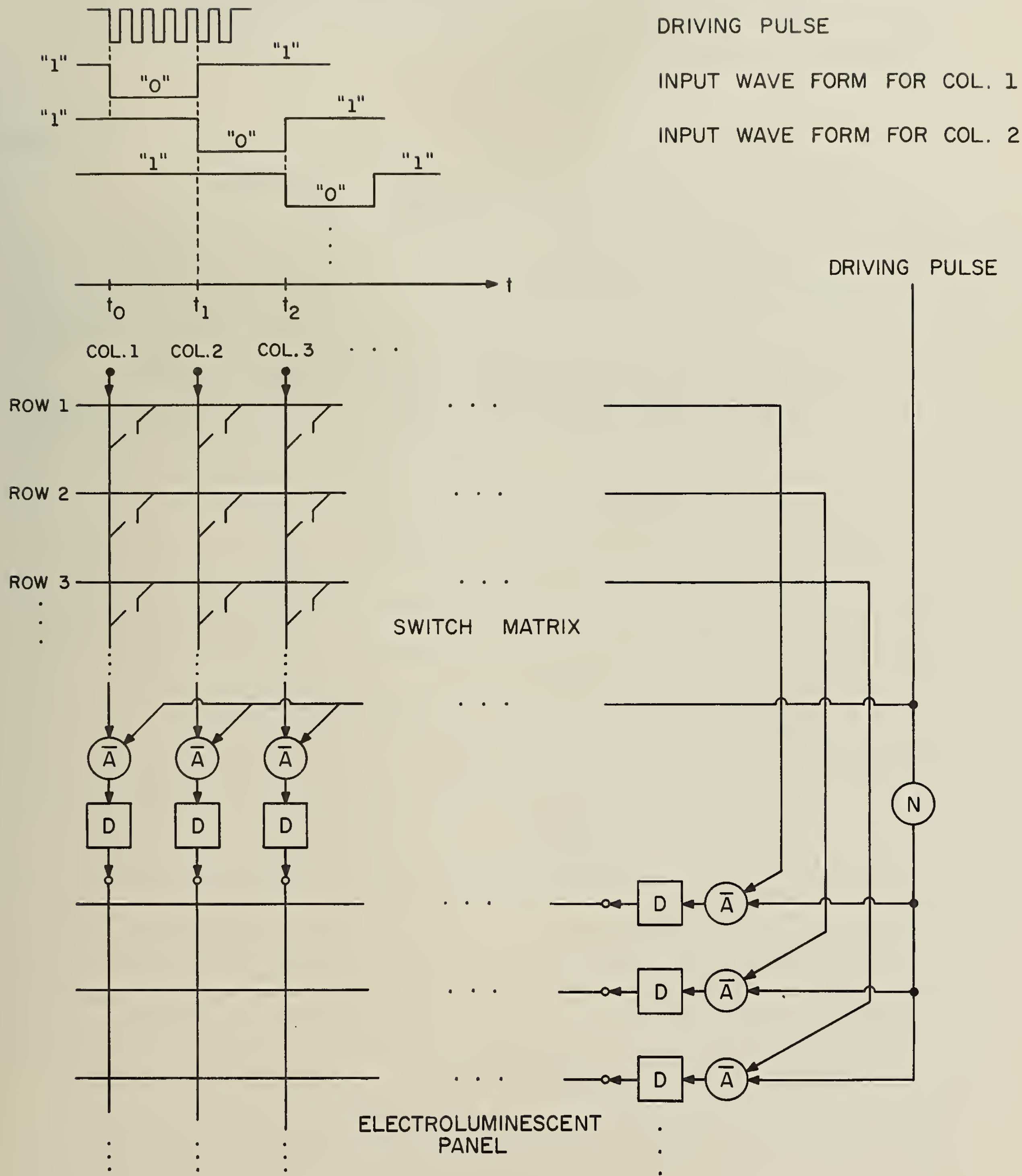


Figure 5. Control System for the Electroluminescent Panel.

1.4 Tunneling Theory

The Ph.D. thesis, "Theory of Electron Transport Processes in Tunnel Diodes" was completed in September. This has already been published as D.C.S. Report No. 214.

M. Faiman

2. HARDWARE SYSTEMS RESEARCH

(Supported in part by the Atomic Energy Commission under Contract No. AT(11-1)-1469).

Summary

The report on the Artrix system that follows is the last to be written by John Esch, William Kubitz, Peter Oberbeck, and David Rollenhagen, before they embark on other projects. They describe final modifications to the system, discuss some aspects of its operation and comment on some of its characteristics.

In the On-Line Fourier Transform project David Casasent and Douglas Sand deal with the optical and environmental properties of the KDP crystal and its associated chamber.

2.1 Artrix System

2.1.1 Line Mode

The original design for the Processor called for lines to be generated parametrically by the equations:

$$x = x_1 + (x_2 - x_1)\sin\omega t; \; y = y_1 + (y_2 - y_1)\sin\omega t \tag{1}$$

(x_1, y_1) and (x_2, y_2) being the end points specified by the operator. This scheme correlated nicely with similar equations, using both $\sin\omega t$ and $\cos\omega t$, for generating circles. But it exhibited the drawback of producing a line of twice the desired length, extending from $(2x_1-x_2, 2y_1-y_2)$ to (x_2, y_2) with (x_1, y_1) as midpoint, owing to negative values of $\sin\omega t$ being allowed. To overcome this, it was proposed to replace (1) by:

$$x = x_1 + (x_2-x_1)\left|\sin\omega t\right| \; ; \; y = y_1 + (y_2-y_1)\left|\sin\omega t\right| \tag{2}$$

using full-wave rectification. However, it later became apparent that this solution was unsatisfactory for the following reasons:

(1) Owing to the unidirectional nature of the sweep the sign of the rectification would depend on the sign of the line slope;

(2) The rectification would have to be referenced to an arbitrary DC level anywhere within the $\pm$ 10 volt analog range;

(3) Intrinsic nonlinearities in the rectification process would cause impermissible distortion in the displayed line.

A third scheme was therefore devised, replacing (2) by the equations:

$$\begin{aligned} x &= x_1 + \tfrac{1}{2}(x_2-x_1)\sin\omega t + \tfrac{1}{2}(x_2-x_1) \\ y &= y_1 + \tfrac{1}{2}(y_2-y_1)\sin\omega t + \tfrac{1}{2}(y_2-y_1) \end{aligned} \tag{3}$$

It is seen in (3) that the zero of $\sin\omega t$ corresponds to the midpoint, rather than the end point, of the line, so that rectification is unnecessary. It should also be noted that the additional DC term added to each coordinate is the same as the amplitude of the corresponding sinusoid.

2.1.2 Video Threshold Circuit

The video signal outputs from the television cameras were improved in two respects with the aid of a video threshold circuit. This provided gain control of the video signal as well as separation of unwanted background noise from the desired information content of the signal.

The levels of the video signals, as they emerged from the cameras, were so much lower than those specified by the manufacturer that most of the information was lost below the black level. Only if the video pulses were of sufficiently large amplitude would the corresponding information appear on the display. Clearly, a threshold circuit with amplification would allow separation of signal and noise and permit the information to show up distinctly on the display. These goals were accomplished with the circuit shown in Figure 1.

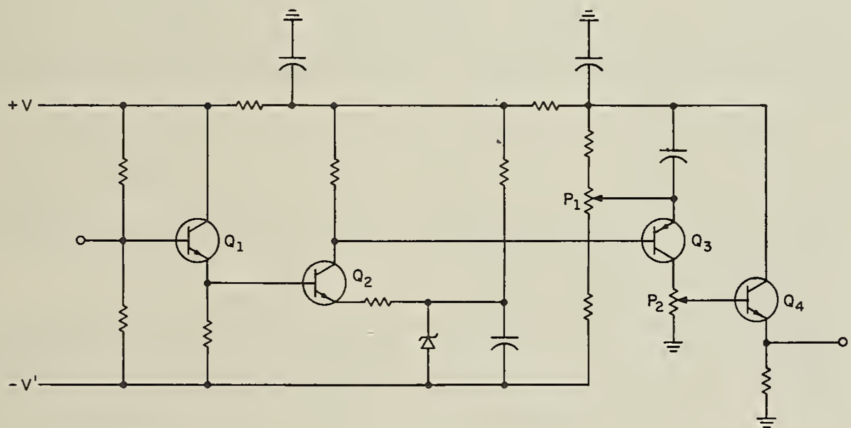


Figure 1. Video Threshold Circuit

The video threshold circuit is DC coupled. The first stage, Q_1, is a biased emitter follower. The second stage, Q_2, is a class B amplifier biased at cutoff by stage Q_1. Q_3 is a threshold amplifier which turns on at a signal level set by potentiometer P_1. The additional amplification due to Q_3 provides a signal of more than sufficient amplitude. The wiper arm of potentiometer P_2 in the collector circuit of Q_3 enables selection of the desired signal level.

2.1.3 Voltage Monitoring

A voltage monitoring circuit has been added to the Artrix system. This circuit constantly monitors the power supply voltages and, in the event of over or under voltage, causes shutdown of the system. In addition, the circuit also monitors a selected voltage from all of the Memo-corder storage units and all of the camera control units for the same purpose.

2.1.4 Drift

Early in the testing phase of the system considerable difficulty was encountered with drift. Although drift was not an unexpected effect in a system of this size and with its low signal levels, it was not clear just what caused the problem. Temperature and line voltage were monitored and the former was determined to be stable after sufficient warm-up time. The line voltage was stable at all times. It was discovered, however, that a warm-up time of about 1-1/2 hours is required to stabilize the system temperature adequately. This long time appears to be due primarily to the fact that the Memo-corders are tube devices requiring a longer warming up time than the transistorized parts of the system. In addition, the cameras are located in the same rack as the storage units. Thus they are not stable until the temperature in that rack stabilizes. Once this occurs the system is very stable.

An additional problem is associated with the camera control units. These units operate at quite high temperatures and do not appear to operate as well under these conditions as at a lower temperature. Unfortunately, the units are supplied by the manufacturer in a completely enclosed package, which does not easily lend itself to cooling from external means.

2.1.5 Trace Speed

There is one remaining problem in the system which will be eliminated before the Artrix project is terminated. This problem exists because of the difference in the writing speeds of the pen and the Processor, and also because of the variation of speeds for the Processor itself. It will be recalled that the Processor writes a 10kc Lissajous pattern into the display memory. This frequency is low enough that it

results in a much slower effective writing speed than for the pen. That is, in the case of the pen the electron beam in the memory moves more rapidly across the storage surface than in the case of the Processor. Even more important is the fact that as the radius of a circle or the length of a line increases the linear velocity of the beam in the memory decreases. Thus a fixed beam intensity is not adequate to allow operation under all conditions. In order to eliminate this problem a circuit is being built which will detect the amplitude of the Processor Lissajous signal and adjust the intensity of the writing beams accordingly.

2.1.6 Reference Crosshatch.

An additional feature added to Artrix was the generation of crosshatched lines on the Monitor for alignment purposes. The condition for doing this is:

$$HMQ_0 HMQ_1 HMQ_2 HMQ_3 \ v \ VMQ_0 VMQ_1 VMQ_2 VMQ_3$$

corresponding to a video signal every sixteenth horizontal and vertical line.

2.1.7 Erasure

The local erase facility of Artrix worked successfully within the limits of resolution of the system. With the system in the Write Mode of operation it had been found necessary to stop deflection of the electron beams in the Memo-corders for several microseconds while writing. This prolongs the write time, hence eliminating the problem of very high writing speeds (refer to previous quarterly report). In the Erase Mode of operation, however, entire frames of information are being transferred between Memo-corders, not single points per frame. Thus it would be impossible to stop deflection of the electron beam for each point in a complete frame of information and expect to transfer, in this manner, the complete frame in 1/60 sec. The result is that information must be written as the electron beam moves along, and storing the information to be erased is more difficult.

2.1.8 Future Extensions

Future processors could easily be expanded by designing function generators. The basic building blocks would include operational amplifiers, digitally controlled analog gates and amplifiers and digital circuits. The digital circuits would set up the interconnections and potentiometer settings for the operational amplifiers to generate a particular function.

Another step forward would be to have the Processor inform the operator of what is going on by means of a character generator. An extension of this idea would be to have the Processor, through the character generator, ask the operator questions and list the possible responses.

The operator could then indicate the answer he desires with a light pen.

John Esch
William Kubitz
Peter Oberbeck
David Rollenhagen

2.2 On-Line Fourier Transform System

In the last quarterly report a system for the on-line display and analysis of the Fourier Transform of a pattern was proposed. Development on the novel solid state light modulating chamber proposed is progressing rapidly and its design details are nearly formulated. To avoid confusion and so that the overall action of the chamber might be better understood, the discussion of the chamber will be deferred until the next report when the information about it is complete.

2.2.1 Light Shutter

In the system diagram previously presented a Kerr Effect light shutter was placed at the laser output to switch the laser beam on and off. This was necessary since the information present at the pickup device is not reliable until the entire pattern has been formed on the KDP surface. The incoming signal is at standard television rate---30 frames per second or approximately 33-1/3 ms/frame. The solution to this problem was to insert a Kerr Cell shutter in the path of the light beam and, thus, through proper pulsing of this modulator, allow the laser light to pass through the KDP chamber only after the pattern on the crystal is complete. Thus the Kerr Cell Shutter would turn the laser on for about 1 ms every 32 ms. The interval of 32 ms would be used to write the pattern on the KDP surface and the remaining frame time to read the pattern.

Thus the following sequence of events would take place. Each frame (33-1/3 ms) there would be a KDP write cycle of 32 ms during which the pattern would be formed on the crystal, and a KDP read cycle of 1-1/3 ms during which the laser would be on and the now completely formed Fourier Transform of the pattern would be transferred to the pickup device and stored there. During the next 32 ms the next frame of information is written on the crystal and, as before, the laser is off. Immediately following the write cycle, the KDP read cycle of 1-1/3 ms occurs during which the laser is on. During this same frame a read and write cycle also occurs on the pickup device. For the first 32 ms of this frame time while the laser is off the previous Fourier Transform is scanned by the pickup tube's electron gun and during the remaining 1-1/3 ms while the laser is on the next frame of information will obviously be transferred

to the pickup tube and stored on its target, ready for scanning as soon as the laser is turned off.

2.2.2 Laser Wavefront

The laser beam after collimation with highly corrected optics has a plane wave output to within 1/10th wave. This very exact wavefront is necessary if a high resolution Fourier Transform of the pattern is to be obtained. The collimated wavefront will be incident on the .01" thick KDP crystal which has on its surface the charge pattern desired. Any variation of the wavefront would seem to be mixed with the desired wavefront produced by the electro-optic effect in the KDP crystal when light shines through it.

The Kerr Cell modulator contains four KDP crystals and, after traversing these, the laser light has a wavefront of questionable flatness. Thus the effect of such a device placed in the light path is being investigated. Simultaneously, other solutions are being investigated such as an image orthicon where it is felt that the image when completely formed can be transferred from the photocathode to the target by modulation in the imaging section. Another solution being investigated is a tube shutter where the transfer of the image can easily be controlled by a modulating grid.

2.2.3 Correction Filter

In applications where a laser is used as the illuminating source for coherent optical data processing, it is necessary that a plane be uniformly illuminated with collimated radiation spatially coherent in either 1 or 2 directions depending on the type of data processing being performed.

For the laser beam with Gaussian intensity distribution, the intensity across an aperture is

$$I(r) = \frac{P}{2\pi a^2} \exp\left\{ - \frac{r^2}{2a^2} \right\} \tag{1}$$

A uniform beam intensity over the area of the KDP crystal is necessary. To obtain a uniform intensity over a circle of radius r_0, the radiation

can be passed through a filter with transmission characteristics:

$$T(r) = \exp\left\{\frac{r^2 - r_0^2}{2a^2}\right\} \tag{2}$$

for $r < r_0$ and $T = 0$ for $r > r_0$. This filter will be obtained by exposing the laser output to a photographic emulsion and then developing the photograph.

2.2.4 Vacuum System

The observed vapor pressure of KDP is not compatible with the vacuum environment required in high resolution cathode ray tube envelopes. For this reason the solid state light modulator chamber must be attached to a vacuum system. Instead of employing the normal mechanical and diffusion pumping stations, an ion vacuum system will be used. In such a vacuum system the desired ultimate pressure of 10^{-7} Torr can easily be achieved without bakeout and no cooling is required after sorption takes place; thus a minimum of liquid nitrogen is needed. Further automatic cooling by built in fans eliminates both water and liquid nitrogen once the ion pump is in operation. But most important, an ion system is very clean, with absolute freedom from hydrocarbon backstreaming.

2.2.5 Outgassing

A clean vacuum system is necessary whenever KDP is to be bombarded by an electron beam. Experience has shown that KDP tends to deteriorate or develop cracks when bombarded by an electron beam. Reports of previous work in electro-optic tube development indicate a high outgassing rate for KDP and KD*P. This may be attributed to either or both of the following two factors:

(1) The basic material has a high vapor pressure,

(2) contaminants trapped in the basic material structure tend to boil off.

Measurements on the vapor pressure are scant, but seem to indicate that it is high, so that the first possibility is likely. The second possibility is also very feasible since KDP and KD*P crystals are grown from an aqueous

solution and it is quite possible that a large amount of water may be trapped in the crystal structure during growth. Autonetics Research Division has produced some experimental evidence which seems to support these contentions, but again very little research seems to have been done in this area. These considerations were instrumental in deciding on a demountable rather than a sealed chamber.

2.2.6 Appendage Pump

Attached to the chamber near the crystal will be a small 1-3ℓ/sec appendage ion pump which will run continuously once the vacuum system has brought the chamber pressure down to the 10^{-7} Torr range. For the appendage pump to maintain the pressure at this level it is necessary to have a clean system. The outgassing of the crystal may prove to be more than the appendage pump can handle. Thus it may become necessary to use a larger pump or devise some means of limiting the outgassing to a low value. Two possible methods are available, either baking out the crystal contaminants or by coating the crystal.

2.2.7 Electro-Optic Crystals

At this point a few words should perhaps be included explaining why KDP is used, since it may appear that the choice of this particular crystal introduces many problems.

The linear electro-optic effect can be described as a change in the crystal's refractive indices which is directly proportional to the applied voltage. The Kerr effect on the other hand is a change in the refractive indices which is a quadratic function of the electric field. There are 20 classes of crystals which do not possess a center of symmetry and all crystals belonging to these classes exhibit the linear electro-optic effect. There are two kinds of electro-optic effect, the longitudinal effect (the light beam and the electric field are parallel) and the transverse effect (the light beam and the electric field are perpendicular). The longitudinal effect is used in our application since the optics are much less involved. In this case the voltage necessary to produce a given change in refractive index can be shown to

be independent of the crystal's dimensions. It can also be shown that the crystal section which is most useful as a shutter is the Z cut with the field applied in the Z direction and the light traveling in the same direction. In this direction the electrically induced retardation is the largest for a given voltage. Furthermore, from symmetry considerations it can be shown that a longitudinal electro-optic effect, free from background birefringence and optical activity, can be obtained only in crystals of two classes, the cubic class $\bar{4}3m$ and the tetragonal class $\bar{4}2m$. Class $\bar{4}3m$ is represented by cubic zinc sulfide, cuprous chloride, gallium arsenide, and HMTA. Class $\bar{4}2m$ is represented by KDP and its isomorphs. Each of these materials has its own intrinsic and practical advantages and disadvantages. Cubic zinc sulfide cannot be grown because of stacking faults; strains and impurities occur in the natural crystals. Cuprous chloride crystals also have strains because they are grown from the melt. The available crystals of gallium arsenide have a very small electro-optic coefficient and are too conducting. HMTA does not exhibit the electro-optic effect consistently. Even if optical activity can be tolerated the electro-optic coefficients of those crystals are small.

Large strain free KDP crystals are available commercially and are transparent from the visible to the ultraviolet. The development of the laser has produced great technological advances in obtaining more homogeneous KDP class crystals of high optical quality. They are the most widely used electro-optic materials primarily because large samples of the necessary optical quality can be provided. This increased use has brought about an increase in the quality (homogeneity, etc.) of the KDP type crystals. The deuterium isomorph KD*P has the largest known room temperature linear electro-optic coefficient and its half wave retardation voltage is 1/2 that of KDP. The magnitude of the change in refractive index is interesting to note. At room temperature it is only about 10^{-4}. This small change is too minute to change the refractive angles significantly but it is sufficient to produce retardation of the order of one wavelength and thereby produce interference phenomena which can be used to modulate light. For example: a relative retardation of one-half wavelength can change the transmission of polarized light from 0 to 100%.

David Casasent
Douglas Sand

3. SOFTWARE SYSTEMS RESEARCH PROGRAM

(This work is supported in part by Contract No. AT(11-1)-1469 of the Atomic Energy Commission and in part by the University of Illinois.)

3.1 Summary

This section provides a description of the work in progress on the Illinois Time-Sharing System which is currently being implemented on the ILLIAC II/PDP-7/IBM 1401 hardware. In the past quarter, the second level BOOTS time-share system has undergone extensive checkout and development in a real time environment. Incorporating SYSFBN (as developed for the proposed 64 console system) and an improved disk usage algorithm, the file manipulation section now operates 4-7 times faster than did the old BOOTS. Numerous loose ends were cleaned up primarily in the area of error detection and handling. The entire system (comprised of the BOOTS supervisor, the TIPSY sub-system, the new unified time-share system loader, and the PDP-7 console servicing system) is essentially operational. However, the new system will not be put on the air until the disk-oriented FORTRAN and NICAP processors, the new relocatable loader, and the disk-resident library are available and running correctly.

This quarter has also seen work in three other areas--an interactive automatic ordinary differential equation numerical integrator, a graphical programming system and the interconnection of a computer controlled terminal which will be part of the display terminal when it arrives. These developments are discussed in Sections 3.10, 3.11, and 3.12 respectively.

Planning has begun for the implementation of a modified version of the time-sharing system on the IBM 360/50/75 system to be delivered in 1967. It is tentatively planned to interface the PDP-7 to the 360/50 in order to provide a file building system based on the present BOOTS system, and an interactive compiler based on the work done on TIPSY, CLIC and SHORTRAN.

The sections of Part 3 are the responsibility of the following people:

Greninger, L. - BØØTS, SYSFBN and FRDISK, Error Messages

Fisher, R. - FF Monitor

Ellis, C. - Sort-Merge, SYSTTD

Berg, M. A. - Loader and Library Search

Lyon, R. - Garbage Collection

Koopman, L. - PDP-7 Programming

Gear, C. W. - Ordinary Differential Equations

Richardson, F., Lo, T. - Graphical Display

Shepard, C. D. - Miscellaneous

Willard, R., Nuspl, S. - Time-Sharing Hardware

C. W. Gear, Principal Investigator

3.2 BØØTS

The user can call forth the various functions and facilities of the 'BØØTS' system by using the 'BØØTS' command language. Every line input from a console is either a command or a line of text for file building. All textual lines begin with a line number for identification while all commands begin with an alphanumeric character. This is the sole distinction between text and commands at the present time.

The system maintains (for each named file) an 'active file' at all times which can be scanned and examined by the appropriate commands. A second file, the 'changes file', is also maintained by the system. All textual lines typed in since the last 'SAVE' command are entered into the 'changes file' and when a 'SAVE' command is given, the 'changes file' is sorted and then merged into the 'active file'.

The 'active file' can be specified by the user to be any file in his library or a blank file in case he wishes to generate a brand new file. As a general rule, the 'active file' at any instance is the file last named in any command. For example, the command 'LØAD' with no file name loads a blank file

as the 'active file'. A subsequent 'SAVE ALPHA' would sort by line number the lines input from the console and then save the sorted file under the name 'ALPHA' in the user's file dictionary. The file 'ALPHA' is then reloaded as the 'active file'. Any lines typed in are henceforth placed in a 'changes file'. Should another 'SAVE ALPHA' be given, first the 'changes file' is sorted by line numbers, and then the 'changes file' and ALPHA are merged by line numbers with precedence going to the 'changes file'. That is to say, should there occur a line in ALPHA and a line in the 'changes file' with the same line number, the line from the changes file is saved while the one from ALPHA is deleted. The file resulting from the merge is then saved under the name ALPHA and reloaded as the 'active file'. Should the user now type in 'FORTRAN BETA', asking file BETA to be translated and a binary deck generated by the FORTRAN compiler, BETA would be compiled and loaded as the 'active file'. Thus we have explained the general rule and definition of 'active file' to be the last file named in a command. It is to be expected that there are exceptions to this rule as to any other. The 'RUN' command deals only with binary decks, and the 'LDCØRE' and 'SVCØRE' commands deal only with core images. Since very little in the way of BCD changes can be meaningful to such files (binary and core images), 'RUN', 'SVCØRE', and 'LDCØRE' do not change the active file.

Other than those commands mentioned above, some of the more newly available commands are:

(1) APPEND FILE1 FILE2 ... FILEN
ALPHA

This command forms a single file from FILE1, FILE2, ..., FILEN by stacking them end to end in the order given, resequencing the resulting file, and then saving the compound file in the user's file dictionary under the name given in the second line (ALPHA in this case).

(2) PRINT NUM1 NUM2

This command will output to the console all the lines of the 'active file' with line numbers between NUM1 and NUM2 inclusive. The line numbers NUM1 and NUM2 are of the form XXX.XXX as are all line numbers. Either NUM1 or NUM2 may be omitted by typing just a decimal point without any accompanying digits. Thus,

'PRINT NUM1 .' will print all lines of the 'active file' with line numbers greater than or equal to NUM1.

'PRINT . NUM2' will print all lines of the 'active file' with line numbers less than or equal to NUM2.

'PRINT' will print all lines of the 'active file'.

Since the line number is printed with each line of text, the 'PRINT' command prints only the first 64 characters of a line.

(3) PRINTA NUM1 NUM2

This command prints the first 128 characters from each line of the text by using two console lines.

(4) PRINTT NUM1 NUM2

This command prints the first 132 characters from each line of the text by using three lines on the console. Thus, an entire 1403 line may be printed.

3.3 FF MØNITØR

The FF or PDPM is the ILLIAC II Monitor which had been adapted to use the SPU channel for console communication rather than use the Multiplexor Special Register. The changes which have been made are given in the section of this quarterly report on ILLIAC II Service, Use, and Program Development.

3.3.1 Communication between ILLIAC and the PDP-7

The PDP-7 software system can handle two types of output messages from ILLIAC--'Data Line' and 'Input Request'. When the PDP-7 receives a 'Data Line', it types the line at the appropriate console until one of three conditions occurs: either a carriage return is encountered or 72 characters are typed or a break is detected. In the first two cases, the 'Output Done' message is sent back to the ILLIAC; in the third case, the 'Break' message is sent back to ILLIAC. In the case of 'Input Request', the PDP-7 again types the data in the buffer but does not reply with 'Output Done' to the ILLIAC. Furthermore, if a break occurs, the PDP-7 attempts to type the entire line again and will continue doing so until the entire line has been typed without a break. ILLIAC will receive no further messages concerning a console which has received an 'Input Request' until the user at the console has typed a line followed by a carriage return.

ILLIAC expects three types of lines from the PDP-7--'Data', 'Output Done', and 'Break'. If the message received pertains to the BØØTS consoles as opposed to the operator console and is not a 'Break', then BØØTS is brought in as soon as possible to process the line. If a 'Break' was received, an 'Input Request' is automatically (by the Monitor) sent back to the console and BØØTS is not informed.

Line buffering is handled inside the PDP and <u>not</u> in the ILLIAC monitor. In fact, if a line is received for a BØØTS console, the input channel cannot be primed again until BØØTS has been brought in to copy the line from the input buffer.

3.3.2 Internal Organization of the FF Monitor

At present, the monitor is set up to handle five consoles. 0 is the operator console number and 1, 2, 3, and 4 are the BØØTS consoles. Two very minor changes must be made in the Monitor if one wants to change the number of consoles that are to be allowed.

PDPØUT is the name of the subroutine which does the actual sending of lines to the SPU channel. The information that must be given to this routine is the console number, the address of the message, and whether to output a line or send an Input Request. The program checks to see if the correct mode is selected on the channel. Certain tables are updated, the message is copied into the output buffer, and the transfer is initiated. Program control then returns to the caller. The output channel is <u>not</u> run under interrupt control.

The input channel is run under interrupt control and when an interrupt occurs or when 'channel end' is detected, then the program PDPINT is given control. The console number received is checked as is the OP code. If the message concerns the operator console then the read from the PDP is given immediately. Otherwise, an attempt is made to bring BØØTS in so that in can handle the line. There are at least 4 conditions when BØØTS cannot be brought in:

(1) if we are now inside of SYSAUX;
(2) if we are now performing a swap;
(3) if BØØTS is already in core;
(4) if the Load-Procedure program is in core.

There are three possible answers to the question of "Who is in core?":

(1) BATCH, meaning any program concerned with processing the normal input/output tapes; e.g., Batch Processor, Nicap, Fortran, Batch user, etc.

(2) BØØTS, meaning the BØØTS core load (the processor);

(3) USER, meaning BØØTS User--i.e., any program associated with a console user.

The block starting with location 16000_8 in the monitor is an overlay block. There is a block associated with each of BATCH, BØØTS, and USER. Among other things this block contains tape tables, disk tables, drum tables, fast register storage, and some program peculiar to the respective core load.

3.4 SYSFBN and FRDISK

SYSFBN is being checked out. The available options of SYSFBN are for the most part specified, and thus a better description of this system subroutine may be given herein.

As was mentioned previously, SYSFBN employs a system of correspondence numbers. This means that whenever a file is declared as an 'ACTIVE' file, the caller must supply a code number (called a correspondence number) which is then associated with that file until the file is closed. Each SYSFBN call contains the correspondence number of the active file on which that SYSFBN call is to be executed. The correspondence number of the desired file must be given in all SYSFBN calls referencing that file as these numbers are the only means SYSFBN has of determining which of the active files is to be referenced. This system of correspondence numbers permits the user to have more than one input (or output) file active at a time, and permits unambiguous temporary references to each of the active files without using the dictionary system and BCD file names. Note that the correspondence numbers in use at any one time must all be unique, at least within an I/O type. In effect, the I/O bit of the call is part of the correspondence number, and only files of the same I/O type as the call are tried when SYSFBN searches for a match on the given correspondence number.

SYSFBN also allows a single file to be both written into and read from through a single declaration, but this feature should be used with care. Variable length records are employed by SYSFBN to increase the packing density on the disk, and if a record is output into a file to a position previously occupied by a different sized record, the entire file will be ruined. These files, called 'READ/WRITE FILES', should always be built of constant-sized records to ensure that the writing of a record into the middle of a file can not ruin the file.

The calling procedure for SYSFBN is:

```
        CAM     1,PARAWD
        CALL    SYSFBN
```

where 'PARAWD' is given by

```
PARAWD  DECQL   OPCODE,BUFFER,EOFEXT,WTEXIT
```

The four parameters associated with a SYSFBN call have the following meanings. The ØPCØDE is decoded bit-by-bit and provides such information as:

a) a system option (or not).
b) a backward (forward) read. (Thus the user can scan back and forth through a file without having to backspace to the start of the file.)
c) a move-and-read option. Thus if this bit is on, first move the pointers and then read, (rather than the more efficient and usual read-and-move which provides an automatic one logical record look-ahead).
d) a 'WRITE' (a 'READ').
e) 'LOOK-AT' the record which the pointers indicate; read but don't move the pointers.
f) the correspondence number.
g) the type of record to be moved. Presently 0, 1, 2, mean binary, BCD, and 1403 line respectively with record size of 21, 11, and 18 words. Types are the same for both input and output calls. If type = 3, then the next record is read regardless of its type, or the given record is output as a binary card.

BUFFER is the address of the first word of the logical record buffer from or to which SYSFBN is to move a record. The buffer should be as long as the maximum size of the record to be moved. The EØFEXT is the full-word address to which SYSFBN will exit if an end-of-file is detected on reading. The WTEXIT is the full-word address SYSFBN is to exit to if the next record in the input file is not of the type specified in the call.

Every logical record transferred by SYSFBN is N+1 words long, where N is a number less than or equal to the actual length of the type of record to be moved. For example, a BCD card is actually 10 words long, but SYSFBN may transfer anywhere from 1 to 11 words, depending on the amount of information on the card. This is because SYSFBN close-packs the logical records when it is building a file, linking them via a system of pointers which permits variable length records to be used. An extra word is transmitted with each logical record to hold the length of the record, the type of the record, and the record's line number if applicable. This extra word is placed at the front of the logical record. Thus if a user has a BCD card to output with only the first 6 words non-blank, he can so inform SYSFBN and SYSFBN will output a record 7 words in length instead of 11 words in length. On the average, if full advantage is taken of this feature, a 40 - 60 percent increase in packing density, and therefore I/O speed, can be achieved.

Because of the extra word SYSFBN needs with each logical record the user's buffer should be N+1 words long, where N = the maximum length of the type of record to be transmitted. The first word of this buffer must be left free, forcing the actual logical record of information to start on the second word of the buffer. This is true for both input and output--the first word of the buffer is used to communicate semi-privileged information about the record to and from SYSFBN. When inputting logical records from an active input file, SYSFBN moves this extra word with each logical record, and, regardless of the compacted size of a record, moves a full-sized record of that type, filling in the tail end with blank words. Therefore any buffer used by SYSFBN for inputting will get completely overwritten each time a new logical record is transferred.

At present there are four meaningful system options in SYSFBN. The first declares a file to be active and must then establish a link between a

file, a given buffer in core, and a correspondence number. The system will also set a busy block flipflop on this buffer disallowing any writes into the buffer other than those given by the system subroutine. The second type rewinds rather than backspaces an input file, thus bringing the first track of the file back into core and resetting all pointers to their initial values. The third type of option closes a file absolutely and is meaningful for both input and output files. For input files, the busy block flipflop is turned off (freeing the block) and all SYSFBN control words belonging to this file are wiped out. For output files, the same things are done but in addition an end-of-buffer code is written following the last logical record output, an end-of-file mark is placed in the buffer, and the buffer is written onto the disk. The fourth and last available system option is similar to option three in that it closes a file, but no EOF's or EOB's are written on output files. This option is useful when using READ/WRITE files as it permits closing such a file while still in the middle of the file.

The calling procedure for FRDISK is:

```
CAM     0,OPCODE
CAM     1,PARAWD
CALL    FRDISK
```

There are three OPCØDES and thus three available options. The track addresses are passed between the calling program and FRDISK in the full word whose address is given in M1 (here denoted as PARAWD). The first option asks for the address of a free track of disk that may be used. Option 2 asks FRDISK to return a file's tracks back to the free track list. Both the first and last track of the file are given in PARAWD and the number of tracks in the file must also be given. The last available option asks FRDISK to change the module from which it is giving out free tracks. This option can be used to good advantage to keep input and output files on different modules and thus minimize disk head movement.

A very complete Programming Memorandum Number 52 entitled "Calling Procedures and Parameters for SYSFBN and FRDISK" was distributed on July 28, 1966.

3.5 Sort-Merge

The Sort-Merge package, SYSSM, which sorts new files and merges new data or other changes into old files (the files being on the disk in the file-by-name format), is completed. The parameters which must be given to this routine include the disk addresses of the first track of the main file, the first track of the table of contents for the main file, and the first track of the file of changes. If no table of contents exists for a file, the file has not yet been sorted; when a sort is called for, the table of contents will be constructed. Upon exit from this routine the (possibly new) disk addresses of the main file and of the table of contents is passed on to the calling program.

3.6 System Operating Procedures and Error Messages

In order to load time-sharing, set SR34 = 0 and bootstrap. Then set SR34 = 6 and hit the return key on the teletype. To get a short reload of the disk, the 'RELØAD TIME SHARE' job will be executed from tape unit 1, channel 5. Time-Sharing will then be signed on for all consoles and batch processing may be begun. For a full reload of the disk, a different special register setting is obeyed. A sequence of jobs starting with a 'CLEAR T.S. DISK' and terminating with 'RELØAD TIME SHARE' will be executed from tape unit 1, channel 5.

There are six possible error messages which may occur during the reload process. The first five listed below can occur only if there is some sort of failure during this reload procedure. The sixth message may occur at any time time-sharing is active (not only during the reload).

(1) "DISK LØAD FAILING"--indicates that the first of two tries at executing the last job listed on the operator's teletype console failed due to disk errors. A second try is made immediately and no operator intervention is necessary. This message is just a warning that things are going badly and that further errors can be expected once time-sharing is running.

(2) "DRUM LØAD FAILING"--indicates that the first of two tries at executing the last job listed on the operator's teletype console (TTY) failed due to drum errors. A second try is made immediately and no operator intervention is necessary. This message is just a warning and is highly unlikely to ever occur. The drum is not prone to error.

(3) "T.S. LØAD, PRØG N, FAILED"--indicates that the second of two tries at executing the last job listed on the TTY failed due to either disk or drum errors. It is always preceded by one of the two messages described above. The number 'N' is the load number of the job being loaded when the failure occurred. After this message is output, the computer will go into a wait loop, waiting for operator intervention. The normal operator action is to try to reload time-sharing again either with the short or full reload (whichever was being done when the failure occurred). Should this message come out repeatedly, a dump should be given. Either a machine failure or a programming error in the last job listed on the TTY can cause this message.

(4) "PRØG N DØESN'T GØ ØN DRUM"--indicates a non-fatal programming error in the last job listed on the operator's console. It occurs when an attempt is made to load something on the drum that shouldn't be there. The programming error which causes this message, although not fatal, may prevent time-sharing from executing properly. No operator intervention is required as the reload will continue as if no error had occurred.

(5) "T.S. LØADER CAN'T LØAD"--occurs only directly after the T.S. LØADER job. It indicates that disk errors have made it impossible to load the T.S. LØADER program onto the disk. The computer will go into a wait loop waiting for operator intervention.

(6) "T.S. ERRØR. DUMP CØRE, DRUM. LIST TAPE 8 FØR SYSTEMS." This message indicates that some strange error has occurred in the time-sharing system. The operator should try to reload time-sharing (first the short and if that fails the full reload). Should the message come out with reasonable frequency, time-sharing should be terminated. Batch processing can be continued as normal if no engineer is available. A programming error may cause this message.

3.7 Binary Card Loader, System Tape-to-Disk Copy

The time-share loader has been debugged and a library search which searches the library in the SYSFBN mode has been added to it. The format of the new binary cards has been changed in one respect; column 13 contains the sign bits and relocation bits for the words in columns 25-28. This was done to maintain compatibility with the assembler.

A subroutine called SYSTTD copies the library tape onto the disk file and changes the format to that needed by the file-by-name system. One file is assigned to each subroutine and the binary card image form required by SYSFBN is produced. The very first file is constructed in order to have available the logical record of User Dictionary System Statistics and a sequence of logical records containing Typical Dictionary Entries and User Dictionary Library Entries. The disk addresses (where these files are placed) are obtained from the FRDISK subroutine.

3.8 Garbage Collection

Several new garbage collection routines were written. One of them, GC, dumps the system-file-by-name area of disk onto two tape units in hope that at best one tape will be error free. GC first rewinds two tapes and reads in the master ID table which is assumed to be on cylinder 0, surface 0 of the disk file. The ID table is then put onto tape and a sumcheck word is computed and recorded on tape. The track addresses of the User's Dictionaries are taked from the ID table. The first User's Dictionary and a sumcheck is then written on tape and the named files belonging to that user are read into core one by one. These files are then dumped onto tape with sumchecks following each record. One tape mark separates the named files of a given user. One User's File Dictionary and his files are separated from another user by two tape marks. The end of the dump is indicated by writing three end-of-file marks.

Since only the used tracks of the disk are dumped and since they are dumped in a compact form, both the dump and the reload are fairly rapid. GC may be used when the new time-sharing system is put on the air.

Two memorandums were distributed. The first describes GC and is dated July 13, 1966. The second gives the calling sequence for DRAG and was put out on August 22, 1966.

3.9 PDP-7 Programming

The SPU PRØCESSØR program for the PDP-7 was nearly completed this quarter. This program permits the use of the PDP-7 in the time-sharing system and runs in conjunction with the SPU INTERRUPT PRØCESSØR. At the present time, only input from console keyboards is accepted, but it is planned to incorporate the use of paper tape as an input medium.

The SPU PRØCESSØR basically involves a scanning process of a specified group of core locations. Bits that are scanned indicate that a character has been received, the echo character from output has been received, transmission on the appropriate ILLIAC input channel has been completed, or a line from ILLIAC is ready to be processed. When a positive indication is given, necessary processing is performed before the scanning process is resumed.

3.10 Ordinary Differential Equations

An interactive system for the on-line numerical solution of ordinary differential equations has been implemented within the ILLIAC II time-sharing system. This is described in the Proceedings of the National ACM Conference, 1966, pp. 43-50. Since that paper was written, new techniques have been discovered which make the integration of stiff ordinary differential equations practical. Work is in progress to adapt these for use in the automatic on-line system. The goal is a system which will accept a symbolic statement of any system of equations, and perform enough analysis such that either a reasonable numerical integration is performed, or the system is rejected. This is only possible for a limited set of all differential equations owing to the finiteness of the method, but it is expected that the counter examples will be thoroughly pathological cases of no interest in practical problems.

The methods for stiff equations will be the subject of a report to be available late this year.

3.11 Graphical Display

One of the reasons for exploring this area is to use a computer controlled display device for the purpose of enabling a programmer to draw flow charts as his source program. These charts will in turn be processed by the

computer to obtain executable object code. In this quarter, a new description of the operating characteristics for the Computer Aided Programming System (CAPS) was written. Included in this description is a discussion of the method of implementation of specific parts of the operating system. This operating system for CAPS is more easily implemented than any previously described operating system and is more general in concept. The CAPS plans to utilize a time-sharing computer as its main processor and a small remote computer which communicates with a display console. The Digital Equipment Corporation's Programmed Buffered Display (PBD)--type 338 is a combination of two pieces of equipment:

(1) The Programmed Data Processor-8 (PDP-8) which is a self-contained general purpose computer, and

(2) The Display Data Processor which controls the display based on the display instructions in memory.

Also produced in this quarter was a preliminary description of a list processing language to be implemented for use in the main computer part of CAPS (i.e., ILLIAC II for the present). This language contains some new features for list processing languages and the necessary power to manipulate multi-dimensional lists.

Both of the above descriptions serve as study aids to indicate improvements that must be made before implementation can be undertaken. Some basic routines to help in the building of a list processor were programmed for the pictorial language to be used on the PDP-8. Main subroutines will then be written in FØRTRAN so that a change to a new principal computer will not require a complete rewriting of the language.

Plans for the next quarter include writing a specification of the operating system for the PBD-338 so that implementation may proceed and this facility may be used further in a study of the remaining problems. Among these problems are: (1) a specification of a two dimensional computer programming language, (2) a complete specification of the meta language or list processor, and (3) some form of implementation of a computer system which utilizes the meta language to process the two dimensional computer programming language.

3.12 Time-Sharing Hardware

3.12.1 Summary

The hardware for the channel equipment dealing with the PDP 7-630 has been completely checked out and is now operational. The summer months were used to clean-up loose ends in the ILLIAC II interplay channel. The PDP-7 has had D. C. marginals run and seems to be in good operational condition. The DEC 630 CCU has been modified to attain better control over those parts of the unit connected to the data-sets.

The first pieces of the Computer Controlled Display System (CCDS) are beginning to arrive and some hardware work is beginning on them. In September a new PDP-8 arrived and it has been checked out. This unit has been modified so that it can serve as a remote console, and it is tied to the PDP-7 via D. C. loops. Information has been transformed to both units successfully. We are waiting for PCB cards from DEC in order to complete the check-out.

3.12.2 Computer Controlled Display System

Ref: Quarterly Progress Report of January, February, March, 1966.

The purchase order for this system was let early in the summer and the first piece of equipment (namely, the PDP-8) has been delivered. The remainder of the 338 display system is to arrive in the last quarter of 1966.

A revision of the PDP-8 has been made in order to make it a remote terminal of the PDP 7-630 time-sharing system. The proposed link to the 630 (communications unit) will operate at about 100 characters/second.

3.12.3 Satellite Processor Communications System

3.12.3.1 Programming Aspects of the SPU Channel

File No. 702 entitled "Programming Aspects of the SPU Channel" was distributed on August 1, 1966, and is very complete. It gives a detailed discussion of the manner in which ILLIAC II and the PDP-7 make use of the Satellite Processor Unit Channel, describes the meaning of the various states of the related special registers, and suggests optimum ways of programming the ILLIAC in order to get maximum information on the state of the channel.

This write-up is also oriented toward the maintenance view and gives all signal names as well as machine orders.

3.12.3.2 Engineering Commentary of the SPU Channel Logic

File No. 704 deals with the operation and description of the channel in particular. Whereas File 702 deals with the interfaces to the PDP-7 and the ILLIAC II, File 704 describes in detail the engineering of the channel proper.

3.12.3.3 Modifications of the DEC 630 Communications Control Unit

The object of File No. 705 is to explain the need for modifications to the 630 as well as to describe exactly what these modifications are. The 630 is that part of the time-sharing system that controls the ports (either direct connect or data set ports). Modifications were required in order to give the system the option of disconnecting a user.

3.12.3.4 Input-Output Hardware Group Memorandum

These IOHGM reports (numbers 32-36) are dittoed and give useful information which can be distributed without too much delay.

Memorandum No. 32--On July 6, 1966, a description was given of the procedure for making useful the read-in-switch on the PDP-7 console. This switch allows for the reading-in of paper tape. However, most tapes produced by the PDP-7 software (standard assemblers, compilers, and editors) are not compatible with loading via the read-in-switch since the software was borrowed from a non-identical machine. The write-up explains debugged programs which do exist and which will generate paper tape that can subsequently be loaded by the switch.

Memorandum No. 33--A description of the special circuit boards needed for cable terminations in the SPU channel is given in Memorandum IOHGM-33 distributed on July 26, 1966, and entitled "DCS Printed Circuit Boards in the DEC PDP-7/630". Four in-house printed circuit boards were built in order to make the PDP-7/630 and the SPU channel function properly.

Memorandum No. 34--IOHGM-34 titled "Idiot Routines for the SPU Channel" was distributed on July 26, 1966. The routines described are handy for debugging the SPU Channel. Whenever the PDP-7 is interrupted by the SPU Channel, the PDP-7 will respond by doing whatever is necessary to get rid of the condition(s) causing the interrupt.

Memorandum No. 35--"A Variable Length Transfer Test for the SPU Channel" is the title of IOHGM-35 published on July 26, 1966. This test specifies the SPU Channel's ability to transfer blocks of data of all possible lengths both to and from the ILLIAC. There is both an ILLIAC II program and a PDP-7 program involved in this check.

Memorandum No. 36--"A Read-Around Data Test for the SPU Channel" is described in IOHGM-36 of July 26, 1966. The test consists of one ILLIAC II program and one PDP-7 program which must work together. The basic test sequence is as follows:

(a) ILLIAC generates a one word test pattern and displays it in AC.

(b) The test word is placed in the output buffer and sent to the PDP-7.

(c) The PDP-7 displays the last quarter word of the test pattern in its AC and sends the word back to ILLIAC.

(d) ILLIAC compares the received word in the input buffer with the transmitted word. If they differ, exit via SYSERR; otherwise return to step (a) above.

The same test pattern is transmitted many times before a new pattern is generated. All worst-case bit patterns for all data paths in the SPU Channel are represented.

3.13 Interactive Compilers

Work has been progressing on SHORTRAN, a line at a time compiler. It is in a debug stage, and a preliminary version is expected to be operational in January. Abstractions from earlier work in this area on CLIC has resulted in a Ph.D. dissertation "Editing Compilers, their Feasibility and Effects" by E. B. Hassler. Report #209, D.C.S., September 1, 1966.

4. NUMERICAL METHODS, COMPUTER ARITHMETIC AND ARTIFICIAL LANGUAGES

(Supported in part by the National Science Foundation under Grant No. NSF-GP-4636.)

4.1 Numerical Methods

The investigation of VSOR (variable successive over-relaxation) for the solution of linear systems approximating elliptic partial differential equations has continued along two lines.

First, the method of VSLOR (variable successive line over-relaxation) for the solution of approximations to Laplace's equation on a 2-dimensional lattice has been further studied. This method, as noted in a previous report, uses a different extrapolation matrix corresponding to each line of lattice points, and the matrices can be chosen so as to make the VSLOR operator nilpotent, i.e., the solution is obtained exactly after a finite number of iterations. In case the lattice is rectangular, there exists a natural coordinate system in which the equations for an $m \times n$ lattice are equivalent to m independent sets of equations, each for a $1 \times n$ lattice. In effect, the 2-dimensional VSLOR operator in this coordinate system is just the direct sum of m 1-dimensional operators. An important consequence of this is the following: For $1 \leq j \leq m$, let $(\omega_{1j}, \omega_{2j}, --- \omega_{nj})$ be a set of n extrapolation factors and let $\rho(\mathcal{L}_j)$ denote the spectral radius of the 1-dimensional operator using $(\omega_{1j}, \omega_{2j}, ---, \omega_{nj})$. Then, if $\rho(\mathcal{L})$ denotes the spectral radius of the 2-dimensional operator determined by $\{\mathcal{L}_j\}$, $1 \leq j \leq m$, we have $\rho(\mathcal{L}) = \max\limits_{1 \leq j \leq m} \rho(\mathcal{L}_j)$.

Moreover, examined in this natural coordinate system, the problem of determining the extrapolation matrices which make the VSLOR operator nilpotent becomes the problem of simultaneously determining m sets of extrapolation <u>factors</u> such that each set makes a certain 1-dimensional operator nilpotent. This 1-dimensional problem, however, has already been fully solved in previous work.

Another interesting property of the nilpotent VSLOR operator for 2-dimensional (not necessarily rectangular) lattices is the following monotonicity property. Let $\mathcal{L}$ be the VSLOR operator defined on a lattice R consisting of k lines of lattice points, and let $\{\Omega_1, \Omega_2, ---, \Omega_k\}$ be the set of extrapolation matrices which make $\mathcal{L}$ nilpotent. Suppose that $\tilde{R}$ is the

lattice obtained by adding ℓ more lines of lattice points after the k-th line of R, and let $\tilde{\mathcal{L}}$ be the VSLOR operator defined on $\tilde{R}$. If $\{\tilde{\Omega}_1, \tilde{\Omega}_2, --, \tilde{\Omega}_k, \tilde{\Omega}_{k+1}, --, \tilde{\Omega}_{k+\ell}\}$ is the set of extrapolation matrices which make $\tilde{\mathcal{L}}$ nilpotent, then $\Omega_i = \tilde{\Omega}_i$, $1 \leq i \leq k$.

The other generalization of SOR and SLOR (operators using a single extrapolation factor) which has been studied is an operator using a different factor for each line of lattice points. Such an operator for an $m \times n$ lattice can be regarded as defined by an extrapolation vector $(\omega_1, --, \omega_n)$. The case n=1 is trivial, and the case n=2 has been fully analyzed. An analytic characterization of the optimal vectors for $n \geq 3$ has not yet been found, nor has the number of optimal vectors been determined for the general case. Operators using extrapolation vectors cannot in general be made nilpotent, of course, as can operators using extrapolation matrices, but the effort to construct optimal operators using extrapolation vectors is considered worthwhile because it is believed that such operators satisfy a stronger monotonicity condition more nearly analogous to that satisfied by operators using a single extrapolation factor. The conjecture is the following: Let $\tilde{\mathcal{L}}$ be the operator defined on the lattice $\tilde{R}$ using the extrapolation vector $(\omega_1, \omega_2, --, \omega_k)$, and suppose that R is any subset of the points of $\tilde{R}$. Let $\mathcal{L}$ be the operator defined on $\tilde{R}$ using the extrapolation vector $(\omega_1, \omega_2, ---, \omega_\ell)$, $\ell \leq k$, where ℓ is the number of lines of lattice points in R. Then $\rho(\mathcal{L}) \leq \rho(\tilde{\mathcal{L}})$. Thus an optimal extrapolation vector for a region $\tilde{R}$ determines good (though not necessarily optimal) extrapolation vectors for any subregion, whereas extrapolation matrices for a region $\tilde{R}$ are useful only for a limited class of subregions.

In the course of the investigations of VSOR described above, two algorithms were discovered for certain standard computations which are more efficient than any algorithms described in the literature, as far as the authors know. The first is for the solution of the tri-diagonal linear systems, and the second is for the implementation of SLOR using a single extrapolation factor.

(D. B. Gillies and L. K. McDowell)

4.2 Arithmetic of Finite State Machines

In the hierarchy of abstract models of computers which ranges from finite automata to Turing machines, one of the main problems has been the characterization of the sets of tapes acceptable by each type of automata. For Turing machines and linear bounded automata, which can convert numbers from one radix representation into any other, the question as to what sets of tapes are acceptable is similar to the question of what sets of integers (written in some radix representation) can be accepted. On the other hand, for pushdown automata and finite state machines, which do not have this ability, the two questions are quite unrelated.

Our work has been directed toward the proof of the following two conjectures:

(1) The sets of integers which can be accepted by finite state machines in any radix number system are exactly the ultimately periodic sets.

(2) The functions computable by finite state machines in any radix number system are exactly the linear functions.

Proofs of results which are somewhat weaker than the above were presented at a seminar on Switching and Automata Theory at this University.

A tutorial paper on "What is Numerical Analysis" was published in the IEEE Student Journal, Vol. 4, No. 5, pp. 26-32 (1966).

(J. Nievergelt)

5. LIBRARY AUTOMATION

A system has been developed which facilitates the use of the Department of Computer Science library for both the user and the librarian. This system consists of a bibliography, author index and KWIC (KeyWord In Context) index and a program which controls circulation.

The indexing programs consist of two main segments. The first of these reads information off of cards, assigns to each document a unique number, and saves it in an easily accessible manner on a tape called the Library Master Tape. From this tape, a bibliography is printed listing for each document (book, chapter of a book, article in a proceedings) the author, title, publisher and date of publication. Also printed is whether a document is contained in another document, and if so, the number of this other document. However, much more information about a document is available, and if necessary, such information can be printed.

Also prepared from the Master Tape is a tape which is used as input to the second segment of the indexing programs. This set of programs prepares the author index and KWIC index. They are the IBM programs, 1401-CR-02X with a few modifications, and the IBM program 1401-SM-060, SORT 7, used for intermediate sorts.

The program to control library circulation is independent of the indexing programs except that the document number assigned in the generation of the Master Tape is available for each book. This number is, however, not necessary, and the program is operational without it. The program is specific in that it is optimally suited for a small library, approximately 10,000 or less books. Its purpose is to minimize the amount of effort required to withdraw a book from the library and to minimize the labors of the librarian. It also makes available to the librarian information which would have previously been difficult and time-consuming to acquire: lists of books withdrawn or due on a certain date, overdue notices, etc.

A card is placed in each book containing the document number, title, copy number and control information. When a person withdraws a book, he writes on the card his name, address and date due. Each morning, the cards from the previous day are taken to the keypunch operators and from each of these cards is prepared a second card containing this information. The deck of such pairs of cards goes into the withdrawal part of the update section of the program deck. During the updating of the library tape, these books are added to the tape. Afterwards the second cards are discarded and the first cards saved. When the book is returned, the librarian places these first cards in the return part of the update section of the program deck, and during the update, these books are removed from the tape. Also at this time, a new copy of the card is punched, and goes into a backup store.

If a book does not have such a card, then the procedure is the same as above except that the user must write the name of the book on the card, and the keypunch operators must punch the first card, too.

This library control system has not yet been incorporated, and so nothing can be said about its effectiveness. It is expected that a few weeks of operation will enable an evaluation of its efficiency to be made.

Lloyd D. Fosdick and Michael A. Coane

6. ILLIAC II SERVICE, USE, AND PROGRAM DEVELOPMENT

(This work is supported in part by Contract No. AT(11-1)-1469 of the Atomic Energy Commission and in part by the University of Illinois.)

6.1 ILLIAC II Program Development

The sections of Part 6 are the responsibility of the following people:

Software System

Aaron, J. - Supervision and Maintenance

Kelly, J. - Disk File System, Disk Dumps, 1401 Program Development

Fisher, R. - Time-Sharing Using the PDP-7

Slivinski, T. - Nicap and Macro

Christopher, J. - Fortran Compiler

Lyon, R. - Batch Processor Plotter Scan

Operations and Maintenance

Carter, C. - Supervision

Huffman, W., Lopeman, H. - Records

Kerkering, T. - CalComp Plotter

Huszar, G. - Test Programming

Krabbe, S. - Supervisor of Maintenance

C. W. Gear, Project Director

Library Development

Heiple, J.

Coane, M.

Chase, S.

Fleck, R. A.

L. D. Fosdick, Project Director

6.1.1 System Program Development

Two significant changes and several minor ones were made to the ILLIAC System this quarter. The system now is disk file oriented and time-sharing uses the PDP-7 computer for communicating with the remote consoles.

6.1.1.1 Disk File System

The Batch Processing side of the ILLIAC II System now runs from the disk file rather than the tape drives. This not only eliminates most tape errors by cutting down on tape manipulation, but it also greatly reduces the time required to sequence from one system program to the next by eliminating tape rewind time. This saving of time is most noticeable when processing short jobs. The system programs are placed approximately in the middle of the disk for efficiency. The main features of the disk system are as follows:

1. Bootstrapping with SR34 = 00003 copies the System Tape on the system area of the disk (module 1, cylinders 150-159); this setting of SR34 loads the disk. All programs are sumchecked.

2. Bootstrapping with SR34 = 00000 or 00001 assumes the system is already on the disk file; hence bootstrap time is short.

3. All system programs read from tape or the disk are sumchecked when they are loaded into core. If errors occur the following message is typed:

   CHKSUM ERR FILE xx RECØRD yy

   where xx and yy are the System Tape file and record numbers of the block in error. If enough errors occur, the message

   RELØAD FRØM SYSTEM TAPE

   will be typed and ILLIAC will be permanently halted. To restart you must bootstrap with SR34 = 3 again.

These changes in ILLIAC II System operation are described in a memorandum dated August 10, 1966.

The programs affected by this change to a disk oriented system are Drum Bootstrap, Tape Bootstrap, Load Monitor, Load Systems, Load Procedure, and Batch Processor.

1. Drum and Tape Bootstraps. These programs are identical logically and read the Load Monitor program from tape or disk depending upon the SR34 setting.

2. Load Monitor. Until the monitor is loaded, errors will result in a halt loop with SR76 displaying the core address of the bad block. On the System Tape, Load Monitor is part of file 0. It is also found as a separate file (22) (with label block) which is copied onto the disk. This program loads the Batch Monitor from tape or from disk and then sets up interrupt conditions and control words. Next either Load Systems is read from tape/disk or SR34 Dumps is read from tape.

3. Load Systems. This program copies Syserr, Monitor Error, and Load Procedure onto the drum from tape or disk. These 4 programs make up both files 4 and 23 of the System Tape. If SR34 = 3, the rest of the System Tape is copied onto the disk starting with file 6 (Batch Processor). A drum table determines which programs are to be loaded on the drum and where they are to be put. Another table, the Load Disk Table, determines where each tape file will be on the disk. The addresses given are for the label block of the file; the data blocks are contained on successive surfaces and must be on the same cylinder. After loading of the drum and disk (if necessary) is completed, DISKWD is set to the user limits.

4. Load Procedure. The program table now contains disk locations instead of tape locations. Because of space limitations, the code for the tape section is overlayed by the disk section. Hence files may not be read from tape by the Load Procedure.

5. Batch Processor. When SR34 = 6 Time Share is signed on. The Batch Processor loads the Time Share Monitor overlays onto drum and core from the Time Share and Batch Offline Monitor file on disk. Otherwise only the Batch Processing Monitor remains in core.

6. Offline Monitor. The Offline Monitor makes up two files of the System Tape. File 2 contains the Batch Offline Monitor, i.e., the top 5 blocks of the Offline Monitor core image. File 21 contains the top 16 blocks of the Monitor core image which includes the Batch blocks and the Time Sharing overlay blocks.

Programming Description Number 5 distributed on August 15 describes the Disk System.

6.1.1.2 Time Sharing Using the PDP-7

An adaptation of the existing Monitor uses the SPU Channel for console communication instead of using the multiplex special register (MSR). The SPU Channel is the interplay channel connecting the PDP-7 to the ILLIAC. Since the PDP-7 is a computer in its own right, it can do a certain amount of the processing of lines which pass back and forth between the time-sharing remote consoles and the ILLIAC. Since the SPU Channel is tied up when the new PDP-7 oriented monitor is part of the system, the PDP-7 is not available to users as a separate computer during time-sharing periods. Roughly five changes were made to the MSR Monitor in order to create this new means of communication.

1. A conversion was made from the MSR's to the SPU Channel.
2. The number of buffers required was reduced to two, one for the input channel and one for the output channel (rather than buffers for each console).
3. The logic was expanded to handle an arbitrary number of consoles.
4. The BOOTS system was separated from the operator console so that now there are four BOOTS consoles and one operator console.
5. The disk error routine has been moved from the relocatable block into the absolute monitor area so that disk error messages during time-sharing are also logged on the operator console.

At present, both the MSR Offline Monitor system and the PDP-7 Offline Monitor system are being maintained. Thus if the PDP-7 is down for engineering, time-sharing can still be run through use of the special registers. Since the original PDP-7 oriented system was put on the air, other special hardware and software features have been added to eliminate operator intervention when

switching between the MSR and PDP-7 system. More information on this new system can be found in the Software Systems Research Section. "A General Description of the Console Handling Software in the FF Monitor" is the title of a Programming Description distributed on August 9.

6.1.1.3 Special Register Disk Dumps

The Special Register 34 Dumps program has been expanded to include the disk files now that the disk is a useful and much used piece of equipment. Any given cylinder on any module may be dumped in octal or decimal (without dumping the entire disk). It is also possible to dump any surface on a given cylinder. In addition, a slight modification to the tape dumping program makes available a single record dump without having to dump to the remainder of the file as well. A memorandum dated July 15, 1966, and titled "SR34 Dumps Program" gives a complete description of the available options.

6.1.1.4 Plotter Scan

Coding is being done on the Batch Processor in order to identify the users with plotter output and to type out the number of inches of paper used by each job. It is planned that each job will have an identification box plotted before the user's information. This box will include the user's name and I.D. number, the date, and the number of inches used.

6.1.1.5 Auxiliary Equipment Errors

When it is impossible to correct an error which has been noted by the drum, tape, and/or disk channels, messages are typed to the operator informing him of the problem. In the past these messages referred to logical unit numbers and often confused the engineers and operators. This has been changed so that presently the physical tape unit or disk file is printed out.

6.1.2 FØRTRAN, the ILLIAC II Compiler

Further changes are being made in the present FØRTRAN compiler in order to make it compatible with the time-sharing system which is still being developed. In particular, work is taking place on the following:

a. All input of data formerly handled by SYSIØ will be handled by SYSFBN.

b. All binary output will be handled by SYSFBN.

c. Sequential line numbers will be generated instead of sequential statement numbers.

d. All auxiliary storage, formerly on the drum, will be on the disk file.

e. A separate file for fatal errors will be generated using SYSFBN in order to enable the console user to obtain fatal error information without the delay of printing the entire program and non-fatal errors listings.

f. The binary card generation routines will create binary card images compatible with the new loader for the developing time-sharing system.

Write-ups and flow charts for FØRTRAN Pass 1, Part 2 have been added to the System Manual and distributed. Part 2 deals with "Transfer of Control".

FØRTRAN was updated in order to correct an error which occurred when trying to compile a very long program. Also, the lengths of certain tables were changed and buffers were linked in order to provide more versatility in the type of program FØRTRAN would compile without increasing the length of the compiler.

6.1.3 NICAP, the ILLIAC II Assembler, and the NICAP MACRO PREPASS

Modifications to NICAP and MACRO which will allow for incorporation of these programs into the new disk time-sharing system are nearly complete. The following changes will only apply to the NICAP which is available from the console--not the batch NICAP.

The listing of NICAP will be different in that an error will be noted immediately after the card which generated it and not after the entire printout. Furthermore, if the error is fatal, it is so noted while being listed.

New binary cards will be generated from the console NICAP. They will be distinguished from the old cards by a 12 punch (as well as the 7-9 punch) in column 1. Column 3 of the new binary cards will contain a binary sequence number for the new loader and column 4 will be the sumcheck of columns 5-72. The last 8 columns of the card will contain an identification code and a sequence number--4 columns being allowed for each. If ENTRY names are specified in the deck, the first 4 characters of the first ENTRY name are used as the identification code. If no ENTRY points are defined, the program automatically generates the identification code "MAIN". The relocation and high order bits of the first quarter word will occur as the 12, 11 punches in column 13. Columns 11 and 12 are blank. The new binary cards will contain only 12 words of information in order to allow for the identification code and sequencing.

The MACRO prepass has been corrected and updated. Outside names may now be put on a MACRO. If a MACRO is used within a MACRO and the inside MACRO is defined after the outside one, the prepass will now generate the complete expansion correctly. MACRO is now a very useful and reliable programming tool.

6.2 Library Programming

6.2.1 ILLIAC II Library Development

During this quarter corrections were made to the following library subroutines:

PTA (An engineering test subroutine)

J5-UØI-CCP1PL-19-NI

The following subroutine was incorporated in the library:

D1-UØI-GQU2-68-NI

IDENTIFICATION--Numerical Quadrature Package for NICAP.

PURPOSE--To evaluate the following types of integrals:

$$\int_a^b f(x)dx$$

$$\int_0^{+\infty} f(x)dx$$

$$\int_{-\infty}^{+\infty} f(x)dx$$

$$\int_D\int f(x,y)dxdy$$

L. D. Fosdick, Project Director
Ruth Ann Fleck
Michael A. Coane

6.3 1401 Program Development

A new tape dump is now on the 1401 system tape. It handles even or odd parity tapes and will print either a BCD character dump or an octal dump. Sense switches are continuously checked so that any new setting is immediately effective. The program is called from the system tape by a TAPE DUMP card.

Also added to the 1401 system tape is a new tape copy and compare program. It should be more reliable than the previously existing programs and gives better error messages.

Programming Description Number 6 distributed on August 15 describes the 1401 Tape Dump Program.

6.4 CalComp, Digital Incremental Plotter

Considering the summer as a low-usage period for the University's computers, the CalComp Plotter was used quite a bit. A table indicating the number of hours run and the number of tapes plotted follows:

Month	No. Tapes Plotted	No. Hours Run
July	224	271
August	177	259
September	113	190

For the next quarter, there will be two full-time Plotter operators. Operators will be on duty from 07:00 to 24:00 Monday through Friday. For the time being, there will be no regularly scheduled Plotter operator on the weekends.

A malfunction developed in the Plotter other than the usual broken chart drive springs. Due to a weak read amplifier, the Plotter would occasionally drop a record of information. Since a new read amplifier board was installed this problem has not recurred.

6.5 Engineering Test Programming

By midsummer the AES (Automatic Engineering System) monitor was nearing completion and preparations were made for the ETS (Engineering Time-Sharing) programs themselves. Tentative plans call for the first core-batch of the ETS system to be a collection of memory tests. These tests would increase

the hardware area under consideration over those areas presently examined by existing programs.

In line with the goal stated above, some of the old memory tests were rewritten. One of the more powerful of these was ØLF (Orbiting Leap-Frog) which maintains four copies of itself in core so that whenever it is ready to jump it can take a majority vote of its copies before generating its new copy. In this manner it ensures (with good probability) the correctness of the new copy.

In addition to ØLF, some of the programs in MASTIC and STRIPE are being rewritten so that both core 0 and core 1 will be tested thoroughly. These include Crosstalk (XT), Mersenne Memory Test (MMT), Double Crosstalk (DXT), and Parity Bit Oscillate (PBO).

Plans were also made for programs of the MTL (Magnetic Tape Library). A disk test, first in a series, named DISK1 was written; it uses the teletype for data input. This program checks the data-flow to the disk channel and includes options which select the data to be sent, the disk channel, and the area of the disk to be tested.

6.6 Engineering Maintenance

6.6.1 ILLIAC II Engineering Log Summary - July, August, September, 1966

Error Analysis - ILLIAC II	July	August	September	TOTAL
Reader	0	0	1	1
Advanced Control	2	5	0	7
AC Power Drop	1	1	0	2
Core 0	1	6	0	7
Core 1	1	2	3	6
Disk Files	3	0	2	5
Drum	0	1	1	2
Delayed Control	0	1	0	1
Clock Interrupt (SRDP)	1	0	0	1
Flow Gating	5	0	0	5
Interplay	2	1	0	3
AEC Tests	0	0	2	2
MAU	1	1	1	3
Power Supplies	3	1	3	7
Power Supplies (I/O)	2	0	0	2
Special Registers	0	1	0	1
SRDP	0	1	0	1
Tape Units	5	1	2	8
Remote Console	0	0	1	1
Unknown	0	2	0	2
Air Conditioning	1	0	0	1
1414 (Channel 5)	1	0	0	1
Teletypes	0	4	0	4
TOTAL	29	28	16	73

6.6.2 Equipment Requiring Servicing

6.6.2.1 IBM Equipment Requiring Services of Customer Engineer

	July	August	September	Total
1401	2	2	0	4
1402	2	2	2	6
Tape Unit "E"	1	1	0	2
Tape Unit "L"	1	0	0	1
Disk File "A"	1	1	2	4
Disk File "B"	2	0	0	2
Tape Unit "F"	0	0	1	1
Tape Unit "B"	0	3	0	3
Total	9	9	5	23

6.6.2.2 Offline Equipment Requiring Repairs

Type Name	July	August	September	Total
Rented				
026 (Interpreter)	1	0	0	1
514 Reproducer	4	1	0	5
026 Key Punch	1	2	1	4
082 Sorter	1	0	1	2
DCS Owned				
TTY KSR (33)	0	0	6	6
TTY KSR (35)	0	0	1	1
TOTAL	7	3	9	19

6.6.3 Scheduled Engineering

1.	Checking transistors	4 hours
2.	Marginal DC voltage tests	3 hours
3.	Component replacement tests (trying new transistors, semiconductors, etc; to replace absolute items)	4 hours
4.	Checking out spare chassis	45 hours
5.	Checking out Core 0 PCB cards	22 hours
6.	D/A converter logic checkout	3 hours

6.6.4 Component Failures

1. Transistors in main machine (main frame, Core 1, interplay, drum, and power supplies)

Main Machine	40,121
Power Supplies	3,592
TOTAL	43,713
Transistors Replaced	9

2. Semiconductor in main machine (diodes, zeners, stabistors, etc.)

TOTAL	81,946
Semiconductors Replaced	6

3. Number of printed circuit cards in I/O equipment

TOTAL	3,006
Replaced	5

6.6.5 Modifications

1. Modified the UN-012 printed circuit cards located in the SRDP cabinet to eliminate the emitter-follower oscillations. The oscillations have been causing interrupt conditions to be set now and then, i.e., protected order, illegal order, etc.

2. The interval timer (clock) found in the SRDP cabinet had a reference level of +12 V. A load resistor was added to drop the output to +6 V. which is proper for a Schmidt trigger input.

3. Changed the cable driver terminations in decoder chassis #2 (D-1060) from a $\overline{\text{C2a}}$ to a $\overline{\text{C3a}}$. Two more decoder chassis are in the process of also being changed.

6.6.6 Causes for Computer Down Time

The main A.C. circuit breaker in the basement tripped, resulting in three (3) hours of down time.

6.7 Log Summaries

6.7.1 ILLIAC II

6.7.1.1 Summary of Use

July, 1966

Scheduled Engineering			50:55
Unscheduled Engineering			89:16
Engineering Development			152:05
Time Sharing Development			190:10
Power Off			80:00
Idle			:50
Miscellaneous (operating, tape rewind, tape skipping, tape mounting, reruns of failures, starts of time sharing)			55:29
Total Use			
Training and Education		4:11	
Training and Education (Relinquish)		4:05	
System Update		2:44	
System Development		72:03	
System Modification and Improvement		:18	
Engineering Maintenance		6:02	
Customer Use			
In Systems	35:42		
Special Short Shots	:10		
Customer Use		35:52	
Total Use			125:15
Total Time			744:00

August, 1966

Scheduled Engineering	64:06
Unscheduled Engineering	84:57
Engineering Development	70:50
Time-Sharing Development	198:47
Power Off	133:55
Idle	1:31
Miscellaneous (operating, tape rewind, tape skipping, tape mounting, reruns of failures, starts of time sharing)	20:17

Total Use

Training and Education		2:10	
Training and Education (Relinquish)		7:48	
System Update		5:21	
System Development		120:08	
Engineering Maintenance		6:11	
Customer Use			
In Systems	29:46		
Special Short Shots	:13		
Customer Use		29:59	
Total Use			171:37
Total Time			744:00

September, 1966

Scheduled Engineering			59:35
Unscheduled Engineering			32:24
Engineering Development			85:14
Time-Sharing Development and Operation			184:04
Power Off			288:00
Idle			8:20
Miscellaneous (operating, tape rewind, tape skipping, tape mounting, reruns of failures, starts of time sharing)			12:40
Total Use			
Training and Education		2:21	
System Update		15:59	
System Development		14:02	
Engineering Maintenance		:20	
Customer Use			
In Systems	16:57		
Special Short Shots	:04		
Customer Use		17:01	
		Total Use	49:43
		Total Time	720:00

6.7.1.2 Summary of Machine Errors

July, 1966

Main Machine		13
Disk Channel		3
Power Supplies		5
Tape Channel		6
A.C. Line Drop		1
Air Conditioning		1
	Total	29

August, 1966

Main Machine		17
Drum		1
Power Supply		2
Special Registers		1
Teletypes		4
Tape Units		1
Unknown		2
	Total	28

September, 1966

Main Machine		8
Disk Channel		2
Power Supplies		3
Tape Channel		2
Remote Console		1
	Total	16

July, 1966

	Number of Runs			Number of Specs			ILLIAC II Usage in Hours		
Dept.	T and Ed	Res	Total	T and Ed	Res	Total	T and Ed	Res	Total
AAE	64	68	132	1	5	6	.975	1.903	2.878
ASTR	000	5	5	0	1	1	.000	1.031	1.031
CE	90	3	93	1	2	3	.895	.066	.961
CHE	000	20	20	0	3	3	.000	.266	.266
EE	19	280	299	2	7	9	.049	7.872	7.921
ILR	000	3	3	0	1	1	.000	.066	.066
MATH	143	000	143	2	0	2	.859	.000	.859
MATRL	000	16	16	0	3	3	.000	.106	.106
NUCE	000	120	120	0	2	2	.000	2.386	2.386
PHYCS	000	291	291	0	12	12	.000	6.626	6.626
PSYCH	000	19	19	0	2	2	.000	.133	.133
TAM	3	113	116	1	4	5	.039	.849	.888
DCS	89	285	374	3	4	7	1.358	14.396	15.754
XSSS*	000	50	50	0	1	1	.000	.172	.172
SUB TOTALS	408	1273	1681	10	47	57	4.175	35.872	40.047
SSUAD	000	1	1	0	1	1	.000	.008	.008
DCSSYS	000	1455	1455	0	10	10	.000	31.771	31.771
TOTALS	408	2729	3137	10	58	68	4.175	67.651	71.826

*Special Short Runs

T and Ed = Training and Education
Res = Research

August, 1966

Dept.	Number of Runs			Number of Specs			ILLIAC II Usage in Hours		
	T and Ed	Res	Total	T and Ed	Res	Total	T and Ed	Res	Total
AAE	114	157	271	1	6	7	1.411	6.832	8.243
AGE	000	3	3	0	1	1	.000	.019	.019
ASTR	000	1	1	0	1	1	.000	.002	.002
CE	11	1	12	1	1	2	.104	.003	.107
CHE	000	2	2	0	2	2	.000	.007	.007
DCS	000	136	136	0	3	3	.000	14.701	14.701
EE	000	147	147	0	10	10	.000	21.540	21.540
MATH	126	000	126	1	0	1	.652	.000	.652
MATRL	000	52	52	0	4	4	.000	.366	.366
MUSIC	000	1	1	0	1	1	.000	.250	.250
NUCE	000	46	46	0	3	3	.000	3.392	3.392
PHYCS	000	54	54	0	8	8	.000	.657	.657
PHYX	000	72	72	0	5	5	.000	.885	.885
PSYCH	000	2	2	0	1	1	.000	.009	.009
TAN	000	24	24	0	3	3	.000	.352	.352
VPP	000	6	6	0	1	1	.000	.140	.140
XSSS	000	40	40	0	1	1	.000	.222	.222
SUB TOTALS	251	744	995	3	51	54	2.167	29.991	32.158
DCSSYS	000	1180	1180	0	11	11	.000	131.934	131.934
TOTALS	251	1924	2175	3	62	65	2.167	161.925	164.092

T and Ed = Training and Education
Res = Research

	Number of Runs			Number of Specs			ILLIAC II Usage in Hours		
Dept.	T and Ed	Res	Total	T and Ed	Res	Total	T and Ed	Res	Total
AAE	54	104	158	1	4	5	.789	2.115	2.904
ASTR	0	5	0	2	2	2	.000	.249	.249
CE	0	8	8	0	1	1	.000	.367	.367
CHE	0	13	13	0	2	2	.000	.156	.156
DCS	50	218	268	3	3	6	.596	8.582	9.178
EE	42	61	103	2	6	8	.392	.347	.739
MATH	31	0	31	2	0	2	.517	.000	.517
MATRL	0	28	28	0	3	3	.000	.345	.345
ME	0	5	5	0	1	1	.000	.021	.021
NUCE	0	43	43	0	1	1	.000	.538	.538
PHYCS	0	24	24	0	3	3	.000	1.766	1.766
PHYX	0	80	80	0	4	4	.000	1.212	1.212
TAM	3	27	30	1	2	3	.069	1.205	1.274
VPP	0	4	4	0	1	1	.000	.046	.046
XSSS	0	32	32	0	1	1	.000	.070	.070
SUB TOTALS	180	652	832	9	34	43	2.363	17.019	19.382
DCSSYS	0	941	941	0	10	10	0.000	21.440	21.440
TOTALS	180	1593	1773	9	44	53	2.363	38.459	40.822

T and Ed = Training and Education
Res = Research

6.7.2 1401-III

6.7.2.1 Summary of Use

July, 1966

Scheduled Engineering		4:30
Unscheduled Engineering		22:08
Maintenance		2:37
Tape Test		2:10
ILLIAC Prep.		318:50
Other (listing, autocoder, sys. copy, reproducing, Cobol, tape printing, etc.)		122:51
Power Off		81:45
Idle		189:09
	Total	744:00

August, 1966

Scheduled Engineering		3:44
Unscheduled Engineering		15:02
Maintenance		11:17
Tape Tests		1:43
ILLIAC Preparation		252:36
Other (listing, autocoder, sys. copy, reproducing, Cobol, demonstrating, operator training, S.P.S., etc.)		78:04
Power Off		151:10
Idle		232:24
	Total	744:00

September, 1966

Scheduled Engineering		6:55
Unscheduled Engineering		6:50
Maintenance		10:30
Tape Test		:15
ILLIAC Preparation		145:25
Other (listing, autocoder, reproducing, Cobol, operator training, load, S.P.S., etc.)		62:56
Power Off		288:00
Idle		199:09
	Total	720:00

6.7.2.2 Summary of Machine Errors

July, 1966

1401 Main Frame	2
1402 Reader Punch	2
729 Tape L	1
Total	5

August, 1966

1401 Main Frame	1
1402 Reader	2
1403 Printer	1
729 Unit M	1
Total	5

September, 1966

1402 Reader	2

7. IBM SERVICE, USE, AND PROGRAM DEVELOPMENT

(Supported in part by the National Science Foundation under Grant No. NSF-GP-700.)

7.1 New Routines

B1-UØI-ATN1-96-SR

Floating Point Single Precision Arctangent. This routine computes arctangent (Y/X) for normalized floating point arguments Y and X.

Revised by W. D. Marquis
July 1, 1966

B2-UØI-TNH1-81-SR

Single precision floating point hyperbolic tangent. This routine computes the hyperbolic tangent of a floating point argument. This routine was adapted from the University of Chicago TANH routine.

Revised by D. Jordan
July 21, 1966

B4-UØI-CUR3-38-SR

Floating point cube root. This routine computes the cube root of a floating point number.

Programmed by David Hutchinson
Revised by C. Hyde
July 26, 1966

I1-UØI-LSR1-132-SR

Program segment selection for multiple core load programs. This subroutine selects the next program segment to be executed in a multiple core-load program. This program was adapted from the University of Michigan Executive System.

Revised by C. Hyde
July 28, 1966

B1-UØI-SIN-133-SR

Single precision floating point sine-cosine. This routine computes the sine or cosine of a floating point argument. It was originally programmed at the University of Chicago.

Revised by C. Hyde
August 9, 1966

Q0-UØI-CHG1-128-SR

Change lines and change cards routine. CHG1LD and CHG1LA allow FORTRAN and MAD programmers to use SYSCLN. CHG1CD and CHG1CA allow FORTRAN and MAD programmers to use SYSCCD. These routines give the programmer complete control over the use of his card and line count estimates. The writeup of the execution coordination routines SYSCLN and SYSCCD should be consulted.

Programmed by Clinton W. Kennel
August 31, 1966

7.2 Log Summaries

Table I - IBM 1401-I

Summary of Use

July, 1966

Scheduled Engineering	4:35
Unscheduled Engineering	12:31
Maintenance	11:43
7094 Preparation	542:24
List/Reproduce	29:45
Code Check	12:46
Tape Dump	:26
SMP	21:46
Idle	14:26
Total	650:22

Table II - IBM 1401-I

Summary of Machine Errors

July, 1966

1402 Card Reader Punch	4
1403 Printer	3
729 V Tape Drives	1
Total	8

Table I - IBM 1401-II

Summary of Use

July, 1966

Scheduled Engineering	1:30
Unscheduled Engineering	1:10
Maintenance	9:38
7094 Preparation	552:18
List/Reproduce	17:42
Code Check	11:24
Tape Dump	2:15
SMP	34:35
Air Conditioning	4:45
Idle	9:40
Total	644:57

Table II - IBM 1401-II

Summary of Machine Errors

July, 1966

1401 Main Frame	1
1402 Card Reader Punch	1
Total	2

Table I - IBM 7094

Summary of Use

July, 1966

Scheduled Engineering				22:46
Unscheduled Engineering				14:58
Maintenance				18:45
Building Power Failure				1:50
Air Conditioning				5:58
Idle				6:34
Miscellaneous (Operator training, tape rewind, System tape mounting, rerun of failing problems, tape skipping, destruction of clock reading)				67:21
TOTAL USE				
Training and Education			15:13	
University Administrative Overhead Use			6:56	
System Modification and Improvement			16:51	
System Updating			1:12	
Customer Use				
In System		461:35		
Relinquish				
AGEC	4:38			
PHYCS	49:22			
Relinquish total		54:00		
Special Short Shots		:26		
Customer Use Total			516:01	
Total Use				556:13
Total Time On				690:25

Table II - IBM 7094

Summary of Machine Errors

July, 1966

716 Printer	1
7110 Instruction Processor	1
7302 Core Storage	1
7607 Data Channel	3
7617 Data Channel Console	1
Building Power Failure	1
Main Floor Air Conditioner	4
	12

7094 Table III July 1966

Dept[1]	Number of Runs T and E[2]	Number of Runs Res	Number of Runs Total	Number of Specs T and E[2]	Number of Specs Res	Number of Specs Total	7094 Usage in Hours-Minutes T and E[2]	7094 Usage in Hours-Minutes Res	7094 Usage in Hours-Minutes Total
AAE	31	139	170	1	4	5	14.6	1 32.5	1 47.2
ACCY	0	2	2	0	1	1	0.0	11.6	11.6
AGE	0	125	125	0	4	4	0.0	2 6.6	2 6.6
AGEC	0	164	164	0	19	19	0.0	9 28.5	9 28.5
AGRON	0	311	311	0	15	15	0.0	8 9.0	8 9.0
ANGEN	0	63	63	0	1	1	0.0	10.2	10.2
ANS	0	164	164	0	3	3	0.0	4 12.5	4 12.5
ANTH	3	0	3	1	0	1	1.8	0.0	1.8
ASTR	0	192	192	0	3	3	0.0	1 31.9	1 31.9
BECBS	0	38	38	0	5	5	0.0	52.7	52.7
BEDRE	0	1	1	0	1	1	0.0	0.2	0.2
CCCHE	0	2	2	0	1	1	0.0	2.2	2.2
CCENE	0	27	27	0	1	1	0.0	1 50.5	1 50.5
CE	933	1275	2208	3	42	45	5 0.1	37 22.4	42 22.6
CERE	0	43	43	0	1	1	0.0	20.7	20.7
CHE	0	1859	1859	0	46	46	0.0	49 16.6	49 16.6
CP	3	0	3	1	0	1	0.9	0.0	0.9
CRC	0	28	28	0	1	1	0.0	52.5	52.5
DCS	32	300	332	2	14	16	14.3	5 27.5	5 41.8
DGS	0	1	1	0	1	1	0.0	0.2	0.2
DOW	0	38	38	0	1	1	0.0	18.7	18.7
DS	0	67	67	0	4	4	0.0	45.2	45.2
ECON	0	234	234	0	8	8	0.0	3 16.9	3 16.9
ED	0	77	77	0	9	9	0.0	2 53.2	2 53.2
EDADM	0	1	1	0	1	1	0.0	0.3	0.3
EDPSY	0	3	3	0	1	1	0.0	3.4	3.4
EDTES	0	57	57	0	1	1	0.0	55.1	55.1
EE	123	807	930	3	23	26	50.8	14 35.3	15 26.2
ENGAD	0	7	7	0	1	1	0.0	14.4	14.4
FOR	0	7	7	0	1	1	0.0	2.8	2.8
FT	0	20	20	0	1	1	0.0	5.2	5.2
GENE	0	7	7	0	1	1	0.0	2.2	2.2
GEOL	0	15	15	0	1	1	0.0	28.6	28.6
GSBA	1	0	1	1	0	1	0.2	0.0	0.2

7094 Table III July 1966 Continued

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
HEC	0	11	11	0	2	2	0.0	51.1	51.1
HED	0	12	12	0	2	2	0.0	24.4	24.4
HORT	0	41	41	0	3	3	0.0	19.4	19.4
ICR	0	304	304	0	3	3	0.0	5 28.9	5 28.9
IE	0	2	2	0	1	1	0.0	0.6	0.6
IED	103	11	114	1	2	3	1 23.4	25.4	1 48.8
ILR	0	11	11	0	1	1	0.0	1 18.5	1 18.5
INADM	0	7	7	0	2	2	0.0	1 18.7	1 18.7
IREC	0	32	32	0	5	5	0.0	13.0	13.0
LIR	0	4	4	0	1	1	0.0	36.8	36.8
MATH	2004	0	2004	3	0	3	6 19.9	0.0	6 19.9
MATRL	0	529	529	0	12	12	0.0	8 47.1	8 47.1
ME	24	515	539	3	16	19	6.1	10 38.0	10 44.2
MKTG	0	14	14	0	1	1	0.0	4.3	4.3
MMPE	0	277	277	0	8	8	0.0	3 18.2	3 18.2
MUSIC	0	64	64	0	1	1	0.0	45.3	45.3
NHS	0	40	40	0	1	1	0.0	47.7	47.7
NUCE	69	509	578	3	7	10	32.9	10 3.3	10 36.3
OIR	0	277	277	0	1	1	0.0	6 12.1	6 12.1
PEM	0	95	95	0	7	7	0.0	5 49.7	5 49.7
PHYCS	0	4190	4190	0	44	44	0.0	260 51.6	260 51.6
PHYX	0	1	1	0	1	1	0.0	0.0	0.0
POLS	0	18	18	0	2	2	0.0	39.1	39.1
PROVS	0	13	13	0	1	1	0.0	1 9.5	1 9.5
PSYCH	9	1478	1487	3	28	31	11.9	29 16.3	29 28.2
REC	0	31	31	0	1	1	0.0	1 19.8	1 19.8
SCONS	0	90	90	0	1	1	0.0	2 15.9	2 15.9
SCS	0	3	3	0	1	1	0.0	4.6	4.6
SGS	0	148	148	0	1	1	0.0	52.2	52.2
SOC	0	1	1	0	1	1	0.0	1.2	1.2
SOCW	0	21	21	0	1	1	0.0	47.8	47.8
SPCH	0	3	3	0	1	1	0.0	1.7	1.7
SPED	0	9	9	0	2	2	0.0	21.9	21.9
SRL	0	81	81	0	1	1	0.0	31.0	31.0
SWS	0	361	361	0	16	16	0.0	5 8.3	5 8.3

7094 Table III July 1966 Continued

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
TAM	29	217	246	2	15	17	15.7	3 47.2	4 2.9
UNIHI	0	134	134	0	2	2	0.0	2 18.5	2 18.5
VPH	0	1	1	0	1	1	0.0	0.5	0.5
VPP	0	8	8	0	1	1	0.0	3.5	3.5
VTED	0	49	49	0	3	3	0.0	15.6	15.6
XSSS[3]	0	126	126	0	1	1	0.0	25.9	25.9
ZOOL	0	22	22	0	3	3	0.0	1 12.7	1 12.7
Subtotal	3364	15834	19198	27	420	447	15 13.4	516 1.1	531 14.5
DCSSY[4]	0	1118	1118	0	22	22	0.0	16 50.7	16 50.7
XDCS[5]	0	81	81	0	1	1	0.0	1 11.6	1 11.6
SSUAD[6]	0	367	367	0	2	2	0.0	6 56.3	6 56.3
Total	3364	17400	20764	27	445	472	15 13.4	540 59.7	556 13.1

1 See list of departmental codes following
2 Training and Education
3 Special Short Shots
4 System Improvement and Modifications
5 System Updating
6 University Administrative Overhead Use

TABLE I - IBM 1401-I

Summary of Use

August, 1966

Scheduled Engineering		8:25
Unschedule Engineering		7:41
Maintenance		12:29
7094 Preparation		561:14
List/Reproduce		20:45
Code Check		7:46
Tape Dump		:52
SMP		23:45
1604 Preparation		:20
Idle		20:77
	Total	664:34

TABLE II - IBM 1401-I

Summary of Machine Errors

August, 1966

1402 Card Reader Punch		6
1403 Printer		2
	Total	8

TABLE I - IBM 1401-II

Summary of Use

August, 1966

Scheduled Engineering		6:55
Unscheduled Engineering		12:51
Maintenance		13:48
7094 Preparation		528:35
List/Reproduce		22:40
Code Check		6:23
Tape Dump		:25
SMP		57:02
Idle		18:46
	Total	667:25

TABLE II - IBM 1401-II

Summary of Machine Errors

August, 1966

1402 Card Reader Punch		8
	Total	8

TABLE I - IBM 7094

Summary of Use

August, 1966

Scheduled Engineering				27:41
Unscheduled Engineering				5:00
Maintenance				18:22
Tape Testing				3:42
Idle				14:05
Miscellaneous (Operator training, tape rewind, system tape mounting, rerun of failing problems, tape skipping, destruction of clock reading)				86:18
Total Use				
Training and Education			13:03	
University Adminstrative Overhead Use			13:24	
System Modification and Improvement			12:50	
System Updating			3:53	
Customer Use				
In system		419:16		
Relinquish				
AGEC	3:53			
BECBS	:17			
CE	1:27			
ECON	:09			
PHYCS	11:58			
PHYX	52:46			
Relinquish Total		70:30		
Special Short Shots		:34		
Customer Use Total			490:20	
Total Use				533:30
Total Time On				688:38

TABLE II - IBM 7094

Summary of Machine Errors

August, 1966

7617 Data Channel Console	1
7302 Core	1
7109 Arithmetic Unit	1
1301 Disk	2
716 Printer	1
Total	6

7094 Table III August 1966

Dept[1]	Number of Runs T and E[2]	Res	Total	Number of Specs T and E[2]	Res	Total	7094 Usage in Hours-Minutes T and E[2]	Res	Total
AAE	8	83	91	1	6	7	9.9	2 25.9	2 35.9
ACCY	0	26	26	0	1	1	0.0	11.2	11.2
ADMRE	0	12	12	0	1	1	0.0	47.8	47.8
AGE	0	189	189	0	4	4	0.0	1 47.3	1 47.3
AGEC	0	177	177	0	17	17	0.0	8 37.6	8 37.6
AGREX	0	2	2	0	1	1	0.0	1.8	1.8
AGRON	0	241	241	0	10	10	0.0	5 49.3	5 49.3
ANGEN	0	59	59	0	1	1	0.0	15.8	15.8
ANS	0	113	113	0	3	3	0.0	2 52.5	2 52.5
ANTH	89	0	89	1	0	1	1 10.8	0.0	1 10.8
ASTR	0	86	86	0	3	3	0.0	33.6	33.6
BECBS	0	70	70	0	3	3	0.0	1 42.5	1 42.5
CCENE	0	54	54	0	1	1	0.0	5 20.6	5 20.6
CE	920	1422	2342	3	42	45	5 3.5	41 12.8	46 16.4
CERE	0	16	16	0	1	1	0.0	15.5	15.5
CHE	6	2034	2040	1	44	45	0.8	55 59.3	56 0.2
CRC	0	25	25	0	1	1	0.0	44.3	44.3
DCS	21	242	263	1	12	13	9.4	4 19.4	4 28.8
DOW	0	54	54	0	1	1	0.0	56.0	56.0
DS	0	103	103	0	5	5	0.0	2 17.3	2 17.3
ECON	12	69	81	1	3	4	10.5	56.5	1 7.1
ED	0	90	90	0	5	5	0.0	2 28.6	2 28.6
EDADM	0	10	10	0	2	2	0.0	16.5	16.5
EDPSY	0	5	5	0	1	1	0.0	1.2	1.2
EDTES	0	34	34	0	1	1	0.0	48.3	48.3
EE	5	625	630	2	17	19	0.8	9 24.1	9 25.0
ENGAD	0	19	19	0	1	1	0.0	18.5	18.5
ENTOM	0	13	13	0	1	1	0.0	7.1	7.1
FOR	0	4	4	0	2	2	0.0	0.8	0.8
FT	0	3	3	0	1	1	0.0	1.0	1.0
GENE	0	3	3	0	1	1	0.0	0.4	0.4
GEOG	0	3	3	0	1	1	0.0	1.0	1.0
GEOL	0	93	93	0	2	2	0.0	59.6	59.6
GSBA	38	0	38	1	0	1	28.7	0.0	28.7

7094 Table III August 1966 Continued

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
HEC	0	11	11	0	2	2	0.0	14.1	14.1
HORT	0	25	25	0	3	3	0.0	35.3	35.3
ICR	0	202	202	0	3	3	0.0	9 52.1	9 52.1
IED	85	108	193	1	2	3	1 33.7	2 29.6	4 3.4
ILR	0	25	25	0	1	1	0.0	29.8	29.8
INADM	0	2	2	0	1	1	0.0	17.9	17.9
IREC	0	32	32	0	2	2	0.0	4.4	4.4
MATH	741	0	741	3	0	3	3 17.3	0.0	3 17.3
MATRL	0	614	614	0	13	13	0.0	8 24.8	8 24.8
ME	65	604	669	2	16	18	26.0	15 18.5	15 44.6
MKTG	0	20	20	0	1	1	0.0	12.4	12.4
MMPE	0	221	221	0	8	8	0.0	2 59.9	2 59.9
MUSIC	0	50	50	0	1	1	0.0	36.5	36.5
NHS	0	192	192	0	1	1	0.0	2 4.3	2 4.3
NUCE	39	417	456	2	8	10	24.4	6 58.3	7 22.7
OIR	0	549	549	0	1	1	0.0	8 58.8	8 58.8
PEM	0	15	15	0	2	2	0.0	1 18.3	1 18.3
PEW	0	12	12	0	2	2	0.0	17.0	17.0
PHYB	0	152	152	0	8	8	0.0	2 46.6	2 46.6
PHYCS	0	1529	1529	0	36	36	0.0	56 48.7	56 48.7
PHYSL	0	6	6	0	2	2	0.0	1.6	1.6
PHYX	0	1851	1851	0	12	12	0.0	146 19.9	146 19.9
POLS	0	10	10	0	2	2	0.0	1 24.0	1 24.0
PSYCH	11	1730	1741	2	33	35	4.1	38 24.8	38 29.0
REC	0	14	14	0	1	1	0.0	31.1	31.1
SCONS	0	153	153	0	1	1	0.0	2 29.8	2 29.8
SCS	0	5	5	0	1	1	0.0	8.3	8.3
SGS	0	156	156	0	1	1	0.0	1 18.8	1 18.8
SOC	0	21	21	0	2	2	0.0	13.4	13.4
SOCW	0	3	3	0	1	1	0.0	32.4	32.4
SPCH	0	5	5	0	2	2	0.0	0.7	0.7
SPED	0	15	15	0	2	2	0.0	33.8	33.8
SRL	0	266	266	0	2	2	0.0	2 44.5	2 44.5
SWS	0	503	503	0	16	16	0.0	7 49.1	7 49.1
TAM	13	267	280	1	15	16	2.2	3 26.0	3 28.3

7094 Table III August 1966 Continued

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
UNIHI	0	333	333	0	2	2	0.0	6 33.8	6 33.8
VPP	0	53	53	0	1	1	0.0	49.0	49.0
VTED	0	63	63	0	3	3	0.0	41.3	41.3
XSSS[3]	0	176	176	0	1	1	0.0	34.4	34.4
ZOOL	0	98	98	0	5	5	0.0	3 17.5	3 17.5
Subtotal	2053	16487	18540	22	411	433	13 3.0	490 20.3	503 23.4
DCSSY[4]	0	1119	1119	0	19	19	0.0	12 50.3	12 50.3
XDCS[5]	0	79	79	0	1	1	0.0	3 52.6	3 52.6
SSUAD[6]	0	281	281	0	2	2	0.0	13 24.1	13 24.1
Total	2053	17966	20019	22	433	455	13 3.0	520 27.3	533 30.4

1 See list of departmental codes following
2 Training and Education
3 Special Short Shots
4 System Improvement and Modifications
5 System Updating
6 University Administrative Overhead Use

Table I - IBM 1401-I

Summary of Use

September, 1966

Scheduled Engineering	2:36
Unscheduled Engineering	9:41
Air Conditioning	1:20
Maintenance	15:55
7094 Preparation	418:27
List/Reproduce	13:24
Code Check	:35
Tape Dump	1:00
SMP	14:56
Idle	61:29
Total	539:23

Table II - IBM 1401-I

Summary of Machine Errors

September, 1966

1401 Main Frame	1
1402 Card Reader Punch	4
1403 Printer	4
1406 Core Storage	1
Total	10

Table I - IBM 1401-II

Summary of Use

September, 1966

Scheduled Engineeeing	2:50
Unscheduled Engineering	5:00
Maintenance	20:40
7094 Preparation	463:18
List/Reproduce	7:48
Code Check	3:22
Tape Dump	2:49
SMP	12:57
Idle	55:23
Total	574:07

Table II - IBM 1401-II

Summary of Machine Errors

September, 1966

1402 Card Reader Punch	3
Total	3

Table I - IBM 7094

Summary of Use

September, 1966

Scheduled Engineering				34:06
Unscheduled Engineering				1:27
Maintenance				16:27
Tape Test				1:51
Air Conditioning				1:45
Idle				59:19
Miscellaneous (Operator training, tape rewind, system tape mounting, rerun of failing problemes, tape skipping, destruction of clock reading)				71:16
Total Use				
Training and Education			3:44	
University Administrative Overhead Use			6:29	
System Modification and Improvement			23:54	
System Updating			2:57	
Customer Use				
In System		325:04		
Relinquish				
AGEC	2:46			
PHYX	13:15			
Relinquish Total		16:01		
Special Short Shots		:15		
Customer Use Total			341:20	
			Total Use	378:24
			Total Time On	564:35

Table II - IBM 7094

Summary of Machine Errors

September, 1966

716 Printer	1
729 Tape Unit	1
1301 Disk	2
Air Conditioning	1
	5

7094 Table III September 1966

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
AAE	2	61	63	1	5	6	2.8	2 2.9	2 5.8
ADV	0	31	31	0	1	1	0.0	32.2	32.2
AGE	1	89	90	1	6	7	0.7	1 25.1	1 25.9
AGEC	0	188	188	0	15	15	0.0	6 29.4	6 29.4
AGRON	31	113	144	1	12	13	5.2	2 31.4	2 36.7
ANGEN	0	1	1	0	1	1	0.0	0.1	0.1
ANS	0	159	159	0	6	6	0.0	5 20.9	5 20.9
ASTR	0	102	102	0	3	3	0.0	46.9	46.9
BECBS	0	187	187	0	4	4	0.0	1 57.4	1 57.4
BINRE	0	10	10	0	1	1	0.0	13.3	13.3
CCCHE	0	2	2	0	1	1	0.0	0.2	0.2
CCENE	0	18	18	0	1	1	0.0	44.0	44.0
CE	46	543	589	4	28	32	12.4	23 21.2	23 33.7
CERE	0	33	33	0	1	1	0.0	51.8	51.8
CHE	3	1516	1519	1	46	47	0.5	47 35.3	47 35.9
CRC	0	7	7	0	1	1	0.0	44.0	44.0
DCS	66	126	192	3	7	10	16.3	2 17.4	2 33.8
DOW	0	35	35	0	1	1	0.0	20.8	20.8
DS	0	52	52	0	2	2	0.0	1 46.5	1 46.5
ECON	0	30	30	0	4	4	0.0	18.1	18.1
ED	0	60	60	0	7	7	0.0	2 17.2	2 17.2
EDPSY	0	1	1	0	1	1	0.0	0.1	0.1
EDTES	0	145	145	0	1	1	0.0	2 14.4	2 14.4
EE	0	415	415	0	18	18	0.0	8 15.5	8 15.5
ENGH	3	0	3	1	0	1	0.2	0.0	0.2
ENTOM	0	4	4	0	1	1	0.0	5.5	5.5
GENE	0	9	9	0	1	1	0.0	8.5	8.5
GEOG	0	7	7	0	1	1	0.0	0.8	0.8
GEOL	0	34	34	0	2	2	0.0	9.8	9.8
GSBA	1	0	1	1	0	1	0.2	0.0	0.2
HEC	0	16	16	0	3	3	0.0	22.0	22.0
HORT	0	57	57	0	5	5	0.0	1 44.5	1 44.5
ICR	0	141	141	0	3	3	0.0	4 55.0	4 55.0

7094 Table III September 1966 Continued

Dept[1]	Number of Runs T and E[2]	Res	Total	Number of Specs T and E[2]	Res	Total	7094 Usage in Hours-Minutes T and E[2]	Res	Total
IE	2	13	15	1	1	2	0.2	10.7	11.0
IED	0	27	27	0	1	1	0.0	9.4	9.4
ILR	0	14	14	0	1	1	0.0	50.5	50.5
IREC	0	34	34	0	3	3	0.0	28.1	28.1
MATH	449	0	449	3	0	3	1 28.7	0.0	1 28.7
MATRL	0	314	314	0	9	9	0.0	11 24.9	11 24.9
ME	45	590	635	5	26	31	36.4	21 47.1	22 23.5
MKTG	0	7	7	0	1	1	0.0	8.5	8.5
MMPE	0	78	78	0	4	4	0.0	39.9	39.9
MUSIC	0	29	29	0	1	1	0.0	37.7	37.7
NHS	0	156	156	0	3	3	0.0	3 27.4	3 27.4
NUCE	0	255	255	0	8	8	0.0	6 49.0	6 49.0
OIR	0	198	198	0	1	1	0.0	3 58.0	3 58.0
PEM	0	2	2	0	1	1	0.0	0.8	0.8
PHYB	0	205	205	0	6	6	0.0	3 29.5	3 29.5
PHYCS	0	1167	1167	0	17	17	0.0	28 45.3	28 45.3
PHYSL	0	39	39	0	2	2	0.0	12.1	12.1
PHYX	0	2154	2154	0	12	12	0.0	99 5.9	99 5.9
PLPA	0	22	22	0	1	1	0.0	20.8	20.8
POLS	0	61	61	0	3	3	0.0	1 16.9	1 16.9
PSYCH	79	832	911	2	25	27	59.1	20 33.2	21 32.3
REC	0	4	4	0	1	1	0.0	1.8	1.8
SCONS	0	158	158	0	1	1	0.0	1 36.6	1 36.6
SCS	0	6	6	0	1	1	0.0	5.0	5.0
SGS	0	99	99	0	1	1	0.0	39.0	39.0
SOC	0	39	39	0	2	2	0.0	1 41.5	1 41.5
SOCW	0	4	4	0	1	1	0.0	2 23.0	2 23.0
SPCH	0	6	6	0	1	1	0.0	1.4	1.4
SPED	0	4	4	0	1	1	0.0	4.5	4.5
SRL	0	59	59	0	3	3	0.0	1 4.1	1 4.1
SWS	0	264	264	0	15	15	0.0	5 7.2	5 7.2
TAM	0	174	174	0	15	15	0.0	2 54.7	2 54.7
UNIHI	0	27	27	0	1	1	0.0	27.7	27.7
VPP	0	15	15	0	1	1	0.0	6.0	6.0
VTED	0	18	18	0	2	2	0.0	32.4	32.4

7094 Table III September 1966 Continued

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
WPGU	0	5	5	0	1	1	0.0	5.6	5.6
XSSS[3]	0	83	83	0	1	1	0.0	15.1	15.1
ZOOL	0	114	114	0	3	3	0.0	22.7	22.7
Subtotal	728	11468	12196	24	366	390	3 43.6	341 20.4	345 04.1
DCSSYS[4]	0	1101	1101	0	20	20	0.0	23 54.4	23 54.4
XDCS[5]	0	73	73	0	1	1	0.0	2 56.7	2 56.7
SSUAD[6]	0	327	327	0	2	2	0.0	6 28.6	6 28.6
Total	728	12969	13697	24	389	413	3 43.6	374 40.1	378 23.8

1 See list of departmental codes following
2 Training and Education
3 Special Short Shots
4 System Improvement and Modifications
5 System Updating
6 University Administrative Overhead Use

Quarterly Summary of Departmental Running Time
July, August, September 1966

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
AAE	41	283	324	3	15	18	27.5	6 1.4	6 29.0
ACCY	0	28	28	0	2	2	0.0	22.9	22.9
ADMRE	0	12	12	0	1	1	0.0	47.8	47.8
ADV	0	31	31	0	1	1	0.0	32.2	32.2
AGE	1	403	404	1	14	15	0.7	5 19.1	5 19.9
AGEC	0	529	529	0	51	51	0.0	24 35.6	24 35.6
AGREX	0	2	2	0	1	1	0.0	1.8	1.8
AGRON	31	665	696	1	37	38	5.2	16 29.8	16 35.1
ANGEN	0	123	123	0	3	3	0.0	26.2	26.2
ANS	0	436	436	0	12	12	0.0	12 26.1	12 26.1
ANTH	92	0	92	2	0	2	1 12.7	0.0	1 12.7
ASTR	0	380	380	0	9	9	0.0	2 52.4	2 52.4
BECBS	0	295	295	0	12	12	0.0	4 32.8	4 32.8
BEDRE	0	1	1	0	1	1	0.0	0.2	0.2
BINRE	0	10	10	0	1	1	0.0	13.3	13.3
CCCHE	0	4	4	0	2	2	0.0	2.5	2.5
CCENE	0	99	99	0	3	3	0.0	7 55.3	7 55.3
CE	1899	3240	5139	10	112	122	10 16.1	101 56.6	112 12.8
CERE	0	92	92	0	3	3	0.0	1 28.1	1 28.1
CHE	9	5409	5418	2	136	138	1.4	152 51.3	152 52.8
CP	3	0	3	1	0	1	0.9	0.0	0.9
CRC	0	60	60	0	3	3	0.0	2 20.9	2 20.9
DCS	119	668	787	6	33	39	40.1	12 4.4	12 44.6
DGS	0	1	1	0	1	1	0.0	0.2	0.2
DOW	0	127	127	0	3	3	0.0	1 35.6	1 35.6
DS	0	222	222	0	11	11	0.0	4 49.2	4 49.2
ECON	12	333	345	1	15	16	10.5	4 31.7	4 42.2
ED	0	227	227	0	21	21	0.0	7 39.2	7 39.2
EDADM	0	11	11	0	3	3	0.0	16.9	16.9
EDPSY	0	9	9	0	3	3	0.0	4.8	4.8
EDTES	0	236	236	0	3	3	0.0	3 57.9	3 57.9
EE	128	1847	1975	5	58	63	51.7	32 15.0	33 6.7
ENGAD	0	26	26	0	2	2	0.0	32.9	32.9
ENGH	3	0	3	1	0	1	0.2	0.0	0.2

Quarterly Summary of Departmental Running Time
July, August, September 1966 Continued

Dept[1]	Number of Runs T and E[2]	Number of Runs Res	Number of Runs Total	Number of Specs T and E[2]	Number of Specs Res	Number of Specs Total	7094 Usage in Hours-Minutes T and E[2]	7094 Usage Res	7094 Usage Total
ENTOM	0	17	17	0	2	2	0.0	12.7	12.7
FOR	0	11	11	0	3	3	0.0	3.6	3.6
FT	0	23	23	0	2	2	0.0	6.2	6.2
GENE	0	19	19	0	3	3	0.0	11.1	11.1
GEOG	0	10	10	0	2	2	0.0	1.9	1.9
GEOL	0	142	142	0	5	5	0.0	1 38.2	1 38.2
GSBA	40	0	40	3	0	3	29.2	0.0	29.2
HEC	0	38	38	0	7	7	0.0	1 27.4	1 27.4
HED	0	12	12	0	2	2	0.0	24.4	24.4
HORT	0	123	123	0	11	11	0.0	2 39.3	2 39.3
ICR	0	647	647	0	9	9	0.0	20 16.1	20 16.1
IE	2	15	17	1	2	3	0.2	11.4	11.6
IED	188	146	334	2	5	7	2 57.2	3 4.4	6 1.7
ILR	0	50	50	0	3	3	0.0	2 38.9	2 38.9
INADM	0	9	9	0	3	3	0.0	1 36.7	1 36.7
IREC	0	98	98	0	10	10	0.0	45.7	45.7
LIR	0	4	4	0	1	1	0.0	36.8	36.8
MATH	3194	0	3194	9	0	9	11 6.1	0.0	11 6.1
MATRL	0	1457	1457	0	34	34	0.0	28 37.0	28 37.0
ME	134	1709	1843	10	58	68	1 8.6	47 43.7	48 52.4
MKTG	0	41	41	0	3	3	0.0	25.2	25.2
MMPE	0	576	576	0	20	20	0.0	6 58.1	6 58.1
MUSIC	0	143	143	0	3	3	0.0	1 59.7	1 59.7
NHS	0	388	388	0	5	5	0.0	6 19.4	6 19.4
NUCE	108	1181	1289	5	23	28	57.4	23 50.6	24 48.1
OIR	0	1024	1024	0	3	3	0.0	19 8.9	19 8.9
PEM	0	112	112	0	10	10	0.0	7 8.9	7 8.9
PEW	0	12	12	0	2	2	0.0	17.0	17.0
PHYB	0	357	357	0	14	14	0.0	6 16.1	6 16.1
PHYCS	0	6886	6886	0	97	97	0.0	346 25.7	346 25.7
PHYSL	0	45	45	0	4	4	0.0	13.7	13.7
PHYX	0	4006	4006	0	25	25	0.0	245 26.0	245 26.0
PLPA	0	22	22	0	1	1	0.0	20.8	20.8
POLS	0	89	89	0	7	7	0.0	3 20.1	3 20.1
PROVS	0	13	13	0	1	1	0.0	1 9.5	1 9.5
PSYCH	99	4040	4139	7	86	93	1 15.2	88 14.3	89 29.6

Quarterly Summary of Departmental Running Time
July, August, September 1966 Continued

Dept[1]	Number of Runs T and E[2]	Number of Runs Res	Number of Runs Total	Number of Specs T and E[2]	Number of Specs Res	Number of Specs Total	7094 Usage in Hours-Minutes T and E[2]	7094 Usage Res	7094 Usage Total
REC	0	49	49	0	3	3	0.0	1 52.8	1 52.8
SCONS	0	401	401	0	3	3	0.0	6 22.4	6 22.4
SCS	0	14	14	0	3	3	0.0	18.1	18.1
SGS	0	403	403	0	3	3	0.0	2 50.1	2 50.1
SOC	0	61	61	0	5	5	0.0	1 56.2	1 56.2
SOCW	0	28	28	0	3	3	0.0	3 43.3	3 43.3
SPCH	0	14	14	0	4	4	0.0	4.0	4.0
SPED	0	28	28	0	5	5	0.0	1 0.3	1 0.3
SRL	0	406	406	0	6	6	0.0	4 19.7	4 19.7
SWS	0	1128	1128	0	47	47	0.0	18 4.7	18 4.7
TAM	42	658	700	3	45	48	18.0	10 8.0	10 26.0
UNIHI	0	494	494	0	5	5	0.0	9 20.2	9 20.2
VPH	0	1	1	0	1	1	0.0	0.5	0.5
VPP	0	76	76	0	3	3	0.0	58.6	58.6
VTED	0	130	130	0	8	8	0.0	1 29.5	1 29.5
WPGU	0	5	5	0	1	1	0.0	5.6	5.6
XSSS[3]	0	385	385	0	3	3	0.0	1 15.6	1 15.6
ZOOL	0	234	234	0	11	11	0.0	4 53.0	4 53.0
Subtotal	6145	43789	49934	73	1197	270	1 32 0.1	1347 41.6	1379 41.7
DCSSYS[4]	0	3338	3338	0	61	61	0.0	53 35.5	53 35.5
XDCS[5]	0	233	233	0	3	3	0.0	8 1.0	8 1.0
SSUAD[6]	0	975	975	0	6	6	0.0	26 49.2	26 49.2
Total	6145	48335	54480	73	1267	340	1 32 0.1	1436 7.3	1468 7.4

1 See list of departmental codes following
2 Training and Education
3 Special Short Shots
4 System Improvement and Modifications
5 System Updating
6 University Administrative Overhead Use

LIST OF DEPARTMENT CODES

IF YOUR DEPARTMENT OR OFFICE DOES NOT APPEAR ON THIS LIST, PLEASE WRITE ITS FULL NAME IN THE DEPARTMENT FIELD (B) ON THE PROBLEM SPECIFICATION FORM EVEN THOUGH IT WILL REQUIRE MORE THAN 6 CHARACTERS.

ACCY	ACCOUNTANCY
ADMREC	ADMISSIONS AND RECORDS
ADV	ADVERTISING
AAE	AERONAUTICAL AND ASTRONAUTICAL ENGINEERING
AGEC	AGRICULTURAL ECONOMICS
AGED	AGRICULTURAL EDUCATION
AGE	AGRICULTURAL ENGINEERING
AGREXT	AGRICULTURAL EXTENSION
AGR	AGRICULTURE
AGRON	AGRONOMY
ANS	ANIMAL SCIENCE
ANTH	ANTHROPOLOGY
ARCH	ARCHITECTURE
ART	ART
ASTR	ASTRONOMY
BIOPH	BIOPHYSICS
BOT	BOTANY
BCMPL	BUREAU OF COMMUNITY PLANNING
BECBSR	BUREAU OF ECONOMIC AND BUSINESS RESEARCH
BEDRES	BUREAU OF EDUCATIONAL RESEARCH
GSBA	BUSINESS ADMINISTRATION, GRADUATE SCHOOL
CZR	CENTER FOR ZOONOSES RESEARCH
CERE	CERAMIC ENGINEERING
CHE	CHEMISTRY AND CHEMICAL ENGINEERING
CRC	CHILDREN'S RESEARCH CENTER
CP	CITY PLANNING
CE	CIVIL ENGINEERING
CCARCH	ARCHITECTURE (CHICAGO CIRCLE)
COMM	COMMUNICATIONS
CSL	COORDINATED SCIENCE LABORATORY
DS	DAIRY SCIENCE
DT	DAIRY TECHNOLOGY
DNSTUD	DEAN OF STUDENTS
DCS	DEPARTMENT OF COMPUTER SCIENCE
DGS	DIVISION OF GENERAL STUDIES L A S
DUE	DIVISION OF UNIVERSITY EXTENSION
ECON	ECONOMICS
ED	EDUCATION
EDPSY	EDUCATION PSYCHOLOGY
EDADM	EDUCATIONAL ADMINISTRATION AND SUPERVISION
EDTEST	EDUCATIONAL TESTING
EE	ELECTRICAL ENGINEERING

ENGLSH	ENGLISH
EDC	EXTENSION DIVISION, COUNSELING
FIN	FINANCE
FT	FOOD SCIENCE
FOR	FORESTRY
GENE	GENERAL ENGINEERING
GEOG	GEOGRAPHY
GEOL	GEOLOGY
GRDCOL	GRADUATE COLLEGE
GSBA	GRADUATE SCHOOL OF BUSINESS ADMINISTRATION
HED	HEALTH EDUCATION
HLTHSV	HEALTH SERVICE
HEC	HOME ECONOMICS
HORT	HORTICULTURE
ILLDMH	ILLINOIS DEPARTMENT OF MENTAL HEALTH
INADM	INDUSTRIAL ADMINISTRATION
IED	INDUSTRIAL EDUCATION
IE	INDUSTRIAL ENGINEERING
IREC	INSTITUTE FOR RESEARCH ON EXCEPTIONAL CHILDREN
ICR	INSTITUTE OF COMMUNICATIONS RESEARCH
IGPA	INSTITUTE OF GOVERNMENT AND PUBLIC AFFAIRS
ILR	INSTITUTE OF LABOR AND INDUSTRIAL RELATIONS
LIR	LABOR AND INDUSTRIAL RELATIONS
LAW	LAW
LIBS	LIBRARY SCIENCE
MKTG	MARKETING
MATRL	MATERIALS RESEARCH LABORATORY
MATH	MATHEMATICS
ME	MECHANICAL ENGINEERING
MRL	MEDICAL RESEARCH LAB
MEDIC	MEDICINE
MRHA	MEN'S RESIDENCE HALL ASSOCIATION
MRHARC	MEN'S RESIDENCE HALL ASSOCIATION ROCKET CLUB
MMPE	MINING, METALLURGY AND PETROLEUM ENGINEERING
MUSIC	MUSIC
NHS	NATURAL HISTORY SURVEY
NUCE	NUCLEAR ENGINEERING
OIR	OFFICE OF INSTRUCTIONAL RESOURCES
PHIL	PHILOSOPHY
PEM	PHYSICAL EDUCATION FOR MEN AND GRADUATE PE
PEW	PHYSICAL EDUCATION FOR WOMEN
PHYX	PHYSICS
PHYSL	PHYSIOLOGY
PLPA	PLANT PATHOLOGY
POLS	POLITICAL SCIENCE
PSYTRY	PSYCHIATRY
PSYCH	PSYCHOLOGY
REC	RECREATION
SHCBRC	SMALL HOMES COUNCIL, BUREAU OF RESIDENTIAL CONSTRUCTION
SOCW	SOCIAL WORK
SOC	SOCIOLOGY

SCONS	SOIL CONSERVATION SERVICE
SPCH	SPEECH AND THEATRE
SGS	STATE GEOLOGICAL SURVEY
SWS	STATE WATER SURVEY
SSU	STATISTICAL SERVICES UNIT
SCS	STUDENT COUNSELING SERVICE
SRL	SURVEY RESEARCH LABORATORY
TAM	THEORETICAL AND APPLIED MECHANICS
USGS	U.S. GEOLOGICAL SERVICE
UNIHI	UNIVERSITY HIGH SCHOOL
VAH	VETERINARY ANATOMY AND HISTOLOGY
VCM	VETERINARY CLINICAL MEDICINE
VMS	VETERINARY MEDICAL SCIENCE
VPH	VETERINARY PATHOLOGY AND HYGIENE
VPP	VETERINARY PHYSIOLOGY AND PHARMACOLOGY
VTED	VOCATIONAL AND TECHNICAL EDUCATION
WPGU	WPGU RADIO STATION
ZOOL	ZOOLOGY

8. PROBLEM SPECIFICATIONS

(Supported in part by the National Science Foundation under Grant No. NSF-GP-700.)

8.1 Research Problem Specifications

During the third quarter of 1966, 151 problem specifications were submitted to the Department for computation. The following brief descriptions of these problems have been prepared for inclusion in this report by those submitting them. T indicates a calculation associated with a thesis.

2101-67001 T Political Science. Community and Voting. This problem deals with the effect of the political characteristics of the local community on how people vote. For example, democrats in democratic areas are less likely to deviate by voting republican than are democrats in republican areas. Data for this project come from two sources--several voting survey samples, and records of aggregate voting and demographic characteristics of communities. With the former set of data, the chief method of analysis is essentially cross-tabulation and rank-order correlation. With the latter set, Pearsonian multiple correlation and multiple regression techniques will be used. (Robert Erikson)

2102-67002 Civil Engineering. Probability Density of Filtered Poisson Process. The purpose of the study is to develop a numerical method for the determination of the probability density function of a filtered Poisson process and the joint probability density function of the filtered Poisson Vector Process for the case when the intensity of the underlying Poisson Counting Process is small. The method of solution consists of representing the weighting function of the filtered Poisson process by line segments; the filtered Poisson Process is then expressed as a sum of independent random variables. The probability density of the filtered Poisson Process can then be expressed in terms of the probability densities of those independent random variables, which are readily obtained. Joint probability density of the filtered Poisson Vector Process can be similarly obtained. The method will be applied to study the response of highway bridges under the passages of vehicles. The arrival of vehicles will be considered as a simple Poisson Process; the response of the bridge system will then be a filtered Poisson Process. The joint probability density of the response of the bridge and its derivative can be used to determine the expected number of threshold crossings of the response, which is essential in the study of life expectancy of highway bridges. (C. C. Tung)

2103-67003 Psychology. Relationship of Reaction Time to Galvanic Skin Resistance. A naive subject and an accomplice expressed judgments in response to thirty-two questions. To some questions the accomplice, who always announced his answers first, expressed very improbable replies. The subject's decision time and galvanic skin resistance were recorded throughout the experimental session. Control subjects received the same treatment except that the accomplice always expressed very probable answers. In both types of groups measures were taken of "conformity behavior," rejection of the accomplice, devaluation of the issue with which the questions dealt, and underrecall of disagreements.

The computer will be used to run correlations between reaction times and galvanic skin resistance for eight different blocks of "trials." These correlations will be run separately for (a) control subjects; (b) experimental subjects; and for (c) six different subsamples of experimental subjects. Ordinary Pearson r will be employed.

The object of the study is to compare results obtained from the use of two measures (reaction time and galvanic skin resistance) which have often been used as indexes of "stress." It is expected that the correlations of the two measures will be a function of the strategy subjects employ in dealing with the situation (e.g., conformity, rejection of the accomplice, etc.). (Ivan D. Steiner)

2104-67004 Civil Engineering. Generalized Sorte-Merge Routine. It is the purpose of this problem to write a generalized sorte-merge routine which will convert information stored in list form into array form. The routine is exclusively a one to one mapping from lists into arrays, and will be a part of the translator-generator being developed by the systems group in the Department of Civil Engineering. (A. Gonzalez)

2105-67005 Psychology. Preferences for Supportive Information. This study examines post-decision preferences for four types of information: (a) favorable to the chosen alternative; (b) favorable to the rejected alternative; (c) unfavorable to the chosen alternative; and (d) unfavorable to the rejected alternative. Two variables are manipulated within a 2 x 2 design: the

irreversibility of the decision and the degree to which the decision will have behavioral consequences. Hypotheses deal with the effects of the manipulations on preferences for these four types of information and with possible consequences of two uncontrolled variables: the extent of preference for one alternative over the other, and the "total favorableness" of the two alternatives. The computer will be used to run correlations (Pearson r's) between each of these two uncontrolled variables and each of five indexes of information preference. Correlations will be run separately for each of the four experimental samples, and for the total sample.

Data were obtained from female college students who chose one of two young men as a "blind date." Half of them had been told that their decision could be reversed when additional information became available to them, and half had been told that their decision could not be reversed. Behavioral consequences were manipulated by telling half of the subjects that the date was purely hypothetical and would not actually occur. The four types of information listed above were subsequently made available to subjects, and a series of preference measures were employed. (Ivan D. Steiner)

2106-67006 T Psychology. A Factor Study of Responses to Visual Stimuli. Responses to eighteen visual stimuli were measured for each subject on fourteen semantic differential scales. The purpose of the study is to determine if any dimensions of the stimuli (color, complexity, angularity) reliably correspond to different ratings on the semantic differential scales. A three-mode factor analysis is considered to be the best method of deriving this information. (Ellen Litt)

2107-67007 Zoology. Energy Requirements of Sparrows During Molt. Captive house sparrows, passer domesticus, were subjected to controlled conditions in the laboratory at three temperatures under four photoperiodic regimes, and measurements made of the weight, fat class, energy metabolized, and nitrogen balance before, during, and after molt. The data will be analyzed by the method of least squares using transformations and multiple regression correlations. (Floyd H. Blackmore)

2108-67008 T Political Science. Analysis of Deviant Voting Behavior. The general objective of this research project is to develop a model which can explain the phenomenon of deviant voting behavior more adequately than existing theory. In attempting to develop an explanatory model of deviant voting behavior data from two different sources will be utilized. First, data from the major election studies of 1952, 1956, 1960, and 1964 of the Survey Research Center of the University of Michigan will be used. These studies were done on a national sample of respondents. Secondly, use will be made of the data from a panel study carried out in Champaign County, Illinois, in 1960 by Professor Denis G. Sullivan of the Department of Political Science of the University of Illinois.

Standard statistical techniques will be used to analyse the data. These techniques will include correlational analysis, cross-tabulation, partition controlling, analysis of variance, analysis of covariance, significance tests, and others.

The results of the computer analysis will be used to (1) identify the various recurring patterns of deviant voting behavior and the relative frequency of occurrence for each of the patterns; (2) to determine what relationships exist between sociological characteristics and deviant voting; (3) to determine what relationship exists between the proximate political environment and deviant voting; (4) to determine what relationship exists between personality structure and deviant voting; and (5) to determine the significance of the above relationships. Then, hopefully, the above findings will be combined into a general explanatory model of deviant voting behavior. (Roy Eugene Miller)

2109-67009 Industrial Education. Descriptive Study of Illinois Practical Nurses. This study is concerned with the educational, demographic, and employment characteristics of practical nurses licensed by the State of Illinois. The data are of record in the offices of the Department of Registration and Education, State of Illinois, Springfield, Illinois. The findings of this study will be disseminated to interested persons and will be used as supplementary information for another study on practical nursing, "An Integrated, Longitudinal Study of Practical Nursing." Analysis will take the form of tabulations, dependency analyses, and interdependency analyses. (Tomlinson)

2110-67010 Civil Engineering. Development of Computer Language for Photogrammetry. A problem oriented language for photogrammetry is being developed to simplify the dialogue between photogrammetrists and a digital computer for the solution of photogrammetric problems. The language (PPL) will allow the user to address the machine with only well known photogrammetric terms and thus will be very easy for the practising photogrammetrist to learn. A complete range of normal photogrammetric production problems can be solved by using an unordered set of required descriptors in photogrammetric terms to supply data to the computer for the solution of a problem. All data input is free of the usual format restrictions of conventional computer solutions. The total system is intended to be housed in the environment of a large scale digital computer and will be an excellent tool in the era of time sharing. (H. F. Soehngen)

2111-67011 Health Education. An Analysis of Health Needs and Problems as Revealed by a Selected Sample of Operation Head Start Children. The purpose of the study is to identify and analyze the common health needs and problems of socially disadvantaged pre-school children in Champaign, Illinois. Tallies of sex, age, race, and questions will be used. The relationship between sex, age, and race as related to each question will be sought. Chi square will be used. The tallies are necessary to find out the distribution of responses and to see which health problems are outstanding to the sex, age, and race. By relating sex, age, and race to the questions, it is hoped to find out specifically which of these fixed variables shows the most significant problems and needs. It is also hoped to find relationships between questions. (W. H. Creswell, Jr.)

2112-67012 T Speech and Theatre. Study of Hierarchy of Phonetic Parameters. Subjects will respond to words and nonsense syllables, spoken by informants and played to them under nine levels of masking noise. A SSUPAC program will then be used to generate frequency tables of the responses of subjects and to convert the tables to phi correlations coefficients in order to discover associations of phonetic characteristics of vowels. (Woolley)

2113-67013 Civil Engineering. Economic Optimization of Water Resource Project. This problem will be the economic optimization of a water resource project. The basis for optimization will be the maximization of net benefits, or benefits minus costs. The structure will be a single-structure, multi-purpose project. Different combinations of purposes at different reservoir sizes will be sampled, using the "Method of Steepest Ascent" on the surface of net benefit, thus determining a maximum point. Data will be obtained from a published report by the Corps of Engineers regarding the Oakley Dam and Reservoir, Sangamon River, Illinois. The computer results will indicate the optimum scale and scope of development. (G. A. Fosbrook, Jr.)

2114-67020 T Economics. Effect of Quality Changes on the Demand for Automobiles. The program is to aid in a regression analysis problem where a dummy variable for quality is added to other variables and tested for its significance. The model will run through once without the dummy variable for a set of different variables to see which are the best to use. From a list of approximately 15 variables, about 6 will be chosen. Then the dummy variable for quality will be added and tested. Least squares, two stage least squares, and limited information estimates of the coefficients, standard errors, and residuals will be required in all cases. Data were obtained primarily from Statistical Abstracts and Automobile Facts and Figures (1965). (Kenneth G. Shay)

2115-67021 T Psychology. An Experimental Study of Social Motives and Group Member Advestment. This project investigates the adjustment of group members as a function of the kind of success (task or interpersonal) which they experience in the group and certain personality measures of social motivation. The data were obtained via questionnaires and observations of the subjects under several experimental treatment conditions. The data will be analyzed by two methods: multiple regression analyses and multivariate analysis of variance. (Doyle Bishop)

2116-67022 Agronomy. Biomathematics. To explain biological responses to various stimuli it is often useful to formulate a mathematical model to describe the responses. Exponential regression models relating yield of corn grain to plant density have been formulated. The estimation of the parameters in this model involves an iterative non-linear least squares procedure which has already been programmed for the IBM 7094. The present study will utilize the computer to simulate field experiments conducted with several varying degrees of precision. That is, the computer will be used to generate a large number of sets of "data" for different values of the parameters and various standard errors. This "data" will then be subjected to the above mentioned least-squares technique to provide estimates of the parameters. This will permit an evaluation of the least squares procedure as to the effects on unbiasedness and variance of the parameters when the "data" has different degrees of precision. (Carmer)

2117-67023 Nuclear Engineering. Laser Plasma Kinetics. A basic study of excited state densities in direct radiation and low voltage arc lasers is planned. This will supplement experimental work currently in process on both lasers. Mathematically the problem reduces to the solution of a set of coupled first order linear differential equations. A major problem is to obtain proper cross sections and life times involved in the constants appearing in these equations. Some experimental values will be used, but auxilliary calculations are also required in many instances. (G. H. Miley)

2118-67024 T Theoretical and Applied Mechanics. Creep Buckling of Circular Rings. The problem is an analytical study of the stability of circular rings and tubes loaded by a uniform external pressure. The structures are to be loaded at temperatures such that creep is the primary mode of deformation. It is assumed that the isochronous stress-strain curve of the material can be approximated by an archyperbolic sine function. The method of solution will be to assume a two-lobed buckled form and then determine the external pressure required to hold the tube in equilibrium. The critical pressure will be determined from the solution of the differential equation for the deflection curve. To accomplish this, it will be necessary to determine

an equivalent flexural rigidity of the tube. The equivalent flexural rigidity can be approximated by determining the slope of a particular moment-curvature interaction curve at zero curvature. A family of moment-curvature interaction curves are obtained from the solution of the force and moment equilibrium equations. The computer will be used to solve the nonlinear force and moment equilibrium equations. (C. C. Schultz)

2119-67025 Bureau of Economic and Business Research. Survey of Financial Characteristics. This research is concerned with the analysis of the financial characteristics of consumers in relation to response and nonresponse errors. The data were collected by personal interviews, using a structured, and very detailed, questionnaire. About 1800 families constituted the original sample which was selected by probability methods. The 7094 computer system will be used primarily to fit multi-variable regression equations to the data; it is also expected that simple frequency counts, cross-classifications, and chi-square tests will be run. (H. Guthrie)

2120-67026 Chemistry and Chemical Engineering. Kinetics Calculations. This is part of the investigation of the mechanisms of the racemization of d-pyruvic acid oximato-bis (2,2'-bipyridine)-cobalt(III) nitrate, and the mechanisms of the exchange of C-14 labelled pyruvic acid oxime between the complex and the free ligand in solution. The calculation involves the determination of the first order rate constants of the racemization process. The data were obtained by measuring the angles of optical rotation of the water solution of the substance at 80° in the course of 127 hours. (B. M. Celap)

2121-67027 Physics. Maintenance of Subroutine Library on the Disk. The great number of subroutines used by the high-energy group of the Physics Department makes it desirable to keep a library of these routines on the disk file. This problem specification is requested so that only one person will be able to rewrite the library. It is hoped that this plan will minimize the chance of accidental destruction of the library. (G. Ascoli)

2122-67028 T Special Education. Data From Study of Special Education Professional Workers. The study attempts to determine the rate of the growth of the number of special education professional workers per one thousand pupils in the 92 districts of the State of Illinois. The computer is to be used to perform a "generalized learning curves" type of analysis based on factor-analysis on a ten year record (1956-1965). Data have been obtained by dividing average daily attendance into the number of teachers based on official records. (Sushila Singhal)

2123-67029 T Electrical Engineering. Investigation of Periodic Structures. The purpose of this study is to investigate the question concerning completeness of the modal solution in a beam waveguide comprised of irises. The reduced problem which is being considered is that of an infinite periodic sequence of slotted metal planes. No spatial variation in one transverse coordinate is assumed. An integral equation involving the unknown field in one slot and the unknown propagation constant is formulated using an appropriate Green's function. A stationary form for the propagation constant is constructed in the Fourier transform plane through the use of Parseval's theorem. It is found that the transform of the field distribution in the slot can be conveniently expanded in a series of radial Mathieu functions of the first kind which automatically satisfy the edge condition in the space plane. The problem then reduces to the matrix equation $A\lambda = B$ where λ is a known function of the propagation constant and A and B have elements which are numerical integrations of the Mathieu functions. Numerically, this work involves computing radial Mathieu functions of the first kind, their associated constants, numerical integrations, matrix inversions, and summing finite series. (G. S. Brown)

2124-67030 Health Education. An Analysis of Health Misconceptions Among 850 New Zealand High School Students. The purpose of the project is to attempt to establish the incidence of health misconceptions subscribed to by male students in various educational programs. A fifty-eight item health misconception test was administered to 850 New Zealand high school boys to

determine the incidence of misconceptions subscribed to. The scores on the misconception test will be examined in relationship to (1) age, (2) grade in school, (3) rank in class, (4) curriculum in which enrolled, and (5) parents' occupation. Standard analysis of variance techniques will be used to determine the extent of the relationships between the misconception test scores and the five variables. Computer output will provide sum of squares for each iteration, the degrees of freedom, the mean squares and all f ratios on which the final analysis will be based. (D. B. Stone)

2125-67031 T Chemistry and Chemical Engineering. Atomic Integral Calculations. One-center, many-electron atomic integrals of interest in the self consistent field - linear combination of atomic orbitals - molecular orbital formalism will be evaluated by the Barnett-Coulson technique. Definite integrals are evaluated using a repeated application of a nine-point Newton-Cotes integration formula. Indefinite integrals are evaluated using repeated applications of Simpson's rule. (D. H. Dugre)

2126-67032 T Chemistry and Chemical Engineering. Gas Reynolds Number Calculation. In conjunction with an experimental program in two-phase air-liquid flow, the air velocity, and subsequently, gas Reynolds Number, is claculated using pressure drop and temperature data from an orifice meter. This simple machine computation minimizes the human error possible in calculations using the ten variables involved in each measurement, saves much tedious calculation time, and the punched data permits easy recalculation should orifice calibrations suddenly change. (D. E. Woodmansee)

2127-67033 Survey Research Laboratory. College Attendance Preferences of Chicago Area Youth. The purpose is to investigate what family characteristics are related to college attendance and to the types of colleges attended by Chicago area youth. Related factors will be identified first by cross-tabulations and later by multiple regressions using survey data collected during June and July, 1966, by the Survey Research Laboratory. (Doris Barr)

2128-67034 Home Economics. Champaign County Food Purchasing Study. As a study which contributes to the North Central Regional Project, Food Purchases and Utilization by Families with Preschool Children, the Department of Home Economics is investigating food purchasing practices of families with preschool children in Champaign County. A representative sample of approximately three hundred households has been drawn. Data are being collected by personal interviews using a revised instrument based upon an earlier pilot study which includes buying practices and use of specific food commodities. An attempt is also being made to determine what effect the presence of preschool children may have upon family food purchasing decisions. The computer will be used to obtain the following: a) frequency distribution and cross tabulation tables, b) the sample error, c) tests of statistical significance. (Glenna H. Lamkin)

2129-67035 Electrical Engineering. Interface and Bulk Phenomena in Solid State Physics. Electronic properties of the insulator-semiconductor interface and the bulk in semiconductor materials are being investigated. Included are detailed studies of the orientation effect of the semiconductor substrate on the interface state concentration and energy level, the fixed oxide charge density, the interface low frequency noise, and surface scattering of electrons and holes. These problems require considerable amount of numerical calculation of both the theoretical analysis and the experimental measurements. The methods involved in the mathematical calculations include numerical integrations of closed integrals and solutions of differential and integral equations. The input data are obtained either from theoretical considerations of the problem on hand or from the experimental measurements obtained in the laboratory. The theoretical computer results will be used to guide experiments and the calculated experimental data from the computer results will be compared with the theoretical calculation. (C. T. Sah)

2130-67036 Material Research Laboratory. Properties of Recombination Centers in Semiconductors. This research program involves the investigation of the electronic properties of defect centers in semiconductors and junctions. The following problems are currently studied: (1) effect of deep impurity centers on the characteristics of p-n junctions, (2) generation-recombination noise from impurity centers in junction- and insulated-gate field-effect-transistors, (3) the determination of the electronic properties of gold centers in silicon from the metal-oxide-semiconductor impedance measurements, (4) optical measurements of the cross sections of capture of electrons and holes by impurity centers, (5) solid solubility of impurities in extrinsic and degenerate semiconductors, and (6) effect of impurity centers and surface states on the energy band of surface barriers. These problems require considerable amount of numerical calculation of both the theoretical analysis and the experimental measurements. The methods involved in these mathematical calculations include the numerical integration of closed integrals and the numerical solutions of differential and integral equations. Special functions subroutines will be employed to an appreciable extent. The input data are obtained either from the theoretical considerations of the problem on hand or the experimental measurements obtained in the laboratory. The theoretical computer results will be used to guide the experiments and the calculated experimental data from the computer will be compared with the theoretical calculations. (C. T. Sah)

2131-67037 T Chemistry and Chemical Engineering. Heats of Interaction From Calorimetry. The heats of acid-base interactions will be measured with a calorimeter. Two techniques to calculate equilibrium constants and standard enthalpies will be used: A graphical, curve fitting method, and the subroutine MINSEK and the experimental heats. (J. Hill)

2132-67038 Economics. Investment Decisions by Firms. This project will analyze investment decisions made by business firms to determine the factors which affect these decisions. Particular emphasis will be placed on determining the relative magnitudes of the effects of output fluctuations, interest rate changes, technical change, and the volume of internal funds.

A distributed lag model will be employed. Econometric model estimation primarily by ordinary least squares will be the major mathematical method employed. Factor analysis will also be utilized. Internal financial data for nine-hundred business firms have been obtained through an arrangement with Standard Statistics Company, a subsidiary of Standard and Poors Corporation. These data include twenty annual observations for each of sixty different financial variables. (Resek)

2133-67039 Department of Computer Science. Bubble Scan. Bubble scan is a portion of a grand research problem, "Automatic Scanning of Bubble Chamber Photograph". The bubble scan program for which the computer will be used, can recognize circles, straight lines, spirals, vertex, etc. The main interest now is to know how well this program can recognize the patterns. (U. Campbell)

2134-67040 Civil Engineering. Dynamic Stresses in Highway Bridges. This problem comprises the theoretical studies supporting the field study of the dynamic stresses induced in highway bridges by moving vehicles, Dynamic Stresses in Highway Bridges, IHR-85, sponsored by the Illinois Division of Highways and the U.S. Bureau of Public Roads. The computer programs to be used were developed in the previous theoretical study, Impact on Highway Bridges, IHR-9. In the analysis the governing differential equations of motion for the bridge and the vehicle are solved using a straightforward numerical integration. The present study will consider the response of a three-span continuous bridge subjected to a three-axle vehicle with arbitrary initial conditions. Some modifications of the existing computer programs will be made. Following this, production runs will be made to compile a set of predictions of behavior to be correlated with field data. (W. H. Walker)

2135-67041 T Physical Education for Men and Graduate PE. The Effects of Progressive Physical Training on Cardiovascular Intervals Under Conditions of Heat and Cold. The purpose of this study is to determine the effects of progressive physical training on reaction to heat and cold stress. Three major cardiovascular intervals were used: tension period, isometric contraction period, and Q-1st heart sound. Simultaneous tracings of the carotid pulse, electrocardiogram and phono cardiogram were made on the Sanborn 4 channel Poly viso recorder at rest, after stress and after five minutes of recovery both before and after a twelve week training period. The cardiovascular time intervals were determined from these tracings for each period. A t test of mean differences will be used to determine significance between these cardiovascular intervals to determine the results of the study, i.e., whether the physical training significantly affected the reaction to the stress or not. (Sharon Ann Plowman)

2136-67042 Home Economics. Calcium Metabolism in Man. The research problem is part of a project on "Numerical Interactions in Human Nutrition". The objective of the overall project is to contribute information furthering understanding of the extent to which minerals or dietary imbalances involving minerals, especially magnesium, may influence calcium metabolism. The SSUPAC program for calculation of least squares will be used to analyze the data from a seventy-five day metabolic balance study for six graduate men students who served as subjects. The computer results will be used to determine the effect of (1) time on calcium excretion, (2) diet 1 versus diet 2 on calcium excretion, and (3) a magnesium supplement in diet 2 on calcium excretion. (Beula McKey)

2137-67043 Nuclear Engineering. Turbulence in Wakes: Porous Media and Liquid Metal Heat Transfer. The evaluation of analytical results with parameter variation is required for the turbulence in wakes and for heat transfer in both liquid metals and in porous media. In the latter cases the use of existing function subroutines is required to evaluate series of Bessel and Kummer functions as obtained in analytical studies. In the former case, evaluation of the analytical results includes standard integration procedures associated with long time averages in turbulence studies. (B. G. Jones)

2138-67044 Nuclear Engineering. Particle Trajectory and Anemometer Data Reduction. The use of analog-to-digital conversion off-campus has been used to provide digital data from particle trajectories and fluid turbulence. The use of digital techniques for analysing these data has been shown to be desirable and adequate. The use of 18,000 word data samples at constant averaging times has been shown to represent the physical phenomena well. Standard statistical procedures are employed to obtain from the data autocorrelations, power spectra, integral scales, dissipative scales, and the various central moments. Each quantity represents a specific physical characteristic of the turbulent nature of the processes being studied. (B. G. Jones)

2139-67045 Institute for Research on Exceptional Children. Re-standardization of Illinois Test of Psycholinguistic Abilities. The purpose of this project is to revise the Illinois Test of Psycholinguistic Ability; determine the statistical characteristics of the test; obtain norms; find intercorrelations between the subtests of the battery, for the different age levels; determine difference between age levels in performance on the various subtests; factor analyze the test items to emplore the structure of the battery, for each age level separately. The test will be intercorrelated with various criterion variables to establish various validity indices for the subtests and the battery as a whole. (Jo Paraskevopoulos)

2140-67046 T Speech and Theatre. Comparison of Four Speech Discrimination Tests for Normal and Impaired Hearing Groups. Many variables may affect a person's speech discrimination ability: (1) the nature of the test material used, (2) the intensity of the presentation, (3) the distortion properties of the communication system, i.e., speaker, transmission system, listener. In the present study comparisons of intelligibility estimates as a function of intensity will be made on four speech discrimination tests (PAL-50, CID-W-22, CNC revised, RHYME test). All comparisons will be made for each of three hearing populations: (1) normals, (2) sensori-neurals, (3) conductives. Analysis of variance will be used in establishing mean scores standard deviations and significance of differences between the four tests within each

of the three experimental populations. Regression analysis will be used in determining correlations between the four tests within each population and in establishing whether one or a combination of the four tests can be used in predicting scores on the remaining tests. (Valerie Farrell)

2141-67047 Physics. Administration. Administration will be a FORTRAN program designed to: (1) handle the bookkeeping of quiz, lab, hour exam, and final exam scores of a large (~ 400-500) class; (2) provide up-to-date information on the relative performance of any student; (3) and to print out suitable charts to aid the lecturer and quiz instructors in determining the progress of any small section within the class. (H. J. Stapleton)

2142-67048 Theoretical and Applied Mechanics. Elastic Interaction of a Point Defect with a Surface Layer. A point defect (e.g. vacancy) is approximated as a center of dilatation and the base material and surface layer are different isotropic materials. The elastic interaction is discussed in terms of the Eshelby force which is represented as the Laplace transform of a specific function peculiar to the problem. The computer will be used to evaluate this integral and study its dependence on the parameters involved. A straight forward application of Simpson's Rule will be employed to evaluate the integral mentioned above. (M. Stippes)

2143-67049 Education. CERLI Needs Survey. The problem is to assess educational needs of a geographical area which encompasses Indiana, most of Illinois, southwest Michigan and a sample of Wisconsin. Survey data is to be collected a large fraction of which is to be interpreted by repeated measures analysis of variance. Results of the analysis will be used to make decisions concerning projects to be undertaken by Cooperative Educational Research Laboratory, Incorporated (CERLI) and to establish a model for continued assessment of regional educational needs. (W. Rogge)

2144-67050 Aeronautical and Astronautical Engineering. Kinetic Theory of Gas-Solid Interactions For Moving Surfaces. The reflections patterns of various types of force fields, which may be used to represent a solid surface in kinetic theory, are under investigation. The reflection pattern is determined by computing the flux of molecules leaving the surface in a given solid angle. To compute this flux, certain integrals of the distribution function must be evaluated. Since these integrals cannot be evaluated in terms of known functions for all types of force fields, when necessary, they will be evaluated using the computer. (L. Sentman)

2145-67051 Economics. Spatial Equilibrium. A five region, four crop spatial equilibrium model is to be solved using the QP-8 program of G. G. Judge. The tableau size is 145 x 290, the largest yet to be used in conjunction with this program. (D. Aigner)

2146-67052 Physiology. Calculation of Metabolic Mixture and Water Balance. The research project is involved in the study of the Physical and Chemical Properties of Human Sweat. The assessment of the quality of the human response to various thermal stresses requires the description of the metabolic mixture and water balance. Equations have been developed to calculate both the metabolic mixture and water balance. In addition, a previous effort to develop a computer program for these equations was successful and will be employed, along with the IBM 7094 and SSUPAC, for their solution. The data required for the necessary calculations were obtained from humans subjected to various thermal stresses, while walking at 3.5 mph on a motor-driven treadmill, in a controlled environmental chamber located in the Human Environmental Research Unit. (R. E. Johnson)

2147-67053 T Mining, Metallurgy, and Petroleum Engineering. Fitting of Least Squares Hyperbola. The general problem is to determine the crystallographic parameters of the mastensitic transformation in an non-platinum alloy. One of these parameters is the orientation relationship, i.e., the angular relationship between the parent and product phases. A Lane back-reflection pattern is obtained which contains spots related to the two phases.

The (x, y) position of the spots relevant to the zones is measured. Using a least squares program, the transverse axis (which is identical to the zone axis of the Lane hyperbola) can be determined. From this the angular relationship between the two structures can be calculated. (E. J. Efsic)

2148-67055 Theoretical and Applied Mechanics. Optimization of Cam Profiles. Optimum cam profiles are to be achieved for the equation

$$\left|\frac{x}{a}\right|^{\alpha} + \left|\frac{y}{b}\right|^{\beta} = 1,$$

where the parameters α, β and the ratio b/a are varied. The cam shape which permits the desired displacement, velocity, and acceleration versus time response is to be achieved. The measure of the success of the project will be a comparison with the best of existing cam profiles. (W. J. Worley)

2149-67056 T Physical Education for Women. The Influence of Laterality on Girls' Ability to Throw a Softball for Distance. The purpose of the present study was to determine the influence of laterality on girls' ability to throw a softball for distance. A battery of eleven test items designed to determine patterns of laterality and the American Association of Health, Physical Education, and Recreation test for the softball throw for distance were administered to one hundred and ninety-five girls of the eighth and ninth grade level. The subjects were divided into three specific groups-homolateral, contralateral, and mixed lateral. The mixed lateral group was sub-divided into specific types of mixed laterality. The softball scores for each group were then compared to determine which group demonstrated the greatest ability. The significance of the relationship between laterality and the ability to throw a softball for distance were determined by analysis of variance. Mean scores for the softball throw for distance were determined for each group and sub-group. Reliability of the laterality test items was established on a test-retest basis. (Barbara Ann Todd)

2150-67057 T Chemistry and Chemical Engineering. Steady State Temp in Boiler Block. The object of this research problem is to determine by an iterative relaxation method an approximate solution to the steady state temperature in a heated boiler block. This is to be accomplished by approximating the exact solution to the Laplace equations for heat conduction by a finite grid scheme. The temperature at each grid point will be calculated by a simple relaxation method. The computer program will iterate over the grid network until an allowable temperature variation in the relaxation process is reached. This program will utilize as data typical temperature variations which might be encountered in the boundaries of a boiler heater block. The temperature results will be used as an aid in designing thermocouple locations for an experimental boiler block to be constructed for chemical engineering research. (J. R. Bragg)

2151-67058 T Mining, Metallurgy, and Petroleum Engineering. Stress Analysis of Geological Features. A stress analysis of different geological features, such as a valley or a mountain range, subject to a tectonic stress field, is conducted. The computer is used for the numerical solutions of the relevant partial differential equations, i.e., the biharmonic equation and the field equations of elasticity in three dimensions. (Hans Pulpan)

2152-67059 T Department of Computer Science. Investigation of Field-Effect Transistors. The problem is to discover advantages and disadvantages of using field-effect transistors in logic systems. The mathematics involved will be mainly the interpretation and tabulation of data. The precise solutions, formulae, etc. will be determined when data is available. (D. E. Newell)

2153-67060 Mining, Metallurgy, and Petroleum Engineering. Stress Distribution From Dynamic Criteria. The purpose of this investigation is to study the resulting stress distributions at the crack tip when the material is stressed. The test specimen is strained at a constant rate with respect to time. The total strain is a sum of two kinds of strain, (i) elastic strain and (ii) plastic strain. Two cases will be studied:

(i) when the total strain is almost equal to the elastic strain i.e., when the plastic strain is very small; and (ii) when the plastic strain is very large. Mathematical expressions have been developed for the above two cases, for relatively simple models. Both the cases involve simultaneous solutions of two equations for two unknowns. The solutions will be obtained for various ranges of parameters. (J. J. Gilman)

2154-67061 Vocational and Technical Education. Project SPAT (Student Perceptions of Attitudes of Teachers). This project is a study of high school students' perception of their teachers' attitude toward them as individual persons. Inquiry into the relation between this perception and other variables will be made: student achievement, sex, grade level, and I.Q. Data have been obtained for 404 students in three Illinois high schools, two rural and one urban. The school administrator provided student marks for the fall semester 1965/66 and student I.Q. scores from office records. The administrator and the home economics teacher assisted in obtaining the students' perception of their teachers' attitudes using a brief instrument devised by this investigator. BIMD (Bio Medical) programs will be used in statistical analysis. (Spitze)

2155-67062 Economics. Fiscal Behavior. This problem involves the derivation and testing of hypotheses about the behavior of Illinois political units in making public finance decisions. Socio-economic characteristics and political structures are used in an attempt to explain the votes of certain Illinois population units with regard to recent finance referenda. The computer will be used for adjustments and transformation of the data from census tracts and voting districts. Processing of the data will involve multiple regression and statistical significance analyses available in SSUPAC. (C. Goetz)

2156-67064 T Physical Education for Men and Graduate PE. Training and the Aerobic Working Capacity in Middle-aged Men. The primary purpose of this investigation was to examine the effects of 5 months of progressive endurance training upon the aerobic working capacity (maximal oxygen intake) of fifteen sedentary, middle-aged men. Secondly, the relationship between the aerobic working capacity and endurance for running (2 mile run) was determined in the experimental group and in another group of highly trained middle-aged men who served as a basis for comparison.

The data were obtained in the Physical Fitness Research Laboratory and the Illinois Animal Science Counter Laboratory (I.L.L.A.S.C.O.) by the investigator and selected staff members of each laboratory. The subjects (experimental) were tested at the beginning, middle, and end of the 5 month training program on the variables under consideration while the highly trained group was tested only once.

The mathematical methods which will be used in this problem include: 1. descriptive statistics (mean, range, standard deviation, coefficient of variation, etc); 2. product moment correlation coefficients and reliability coefficients; 3. linear and stepwise multiple regression; 4. analysis of variance (or non-parametric Friedman test for matched groups); 5. t test (or non-parametric Wilcoxen test for matched samples); 6. possibly causal analysis.

The computer results will be used to compute the various measurements from the raw data and to analyse the significance of the changes due to the exercise program and the differences between sedentary and highly trained groups of men. (Paul M. Ribisl)

2157-67065 T Sociology. Adult Sibling Interaction. The project is a sociological case study of the interaction and gift exchange patterns between 16 married couples and their adult siblings and first cousins. From 5 to 14 personal interviews were conducted with each couple with the average interviewing time per couple being about 15-20 hours. Each couple was asked a series of questions about the interaction patterns and gift exchange patterns that existed between husband and wife and their relatives. Each respondent averaged about fifty relatives.

The interaction and gift exchange between the 16 couples and their relatives will be analyzed using such variables as: 1. sex of respondents and their relatives; 2. age of respondents and their relatives; 3. religion of respondents and their relatives; 4. socio-economic position of respondents; 5. feelings of closeness between respondents and their relatives; 6. education of the respondents; 7. rate of contact between respondents and their relatives.

The mathematical methods to be used in the analysis of the data include frequency distributions, correlational analysis, and factor analytic techniques. The results of these analyses will be used to study the differential effects which the above seven variables have on kinship interaction and gift exchange. (Jerry M. Lewis)

2158-67066 T Education. The Relationship of Selected Variables to the Success or Failure of School Tax Referenda. This study is an attempt to devise a formula to classify school tax referenda into those which are successful and those which fail. Data on 19 variables were collected for 175 school districts holding 218 tax elections, between July 1, 1963 and June 30, 1964. These variables cover economic, demographic, geographic, and political facets of the school district. The demographic variables: median family income, years of schooling completed and the percent of professional workers were taken from U.S. Census Reports 1960, Vol. 15. The data concerning the date of the election, the type of election, its success or failure were secured from the Research Division of Illinois Education Association. The data regarding the total tax rate were secured from the Department of Revenue, state of Illinois. The other data: teacher-pupil ratio, assessed valuation per pupil and in total, the area in square miles, the per cent of growth, the average daily attendance, school tax rates, per capita cost, bonds outstanding and percent of bonded indebtedness were furnished by the Office of State Superintendent of Public Instruction. Supplementary data were secured by contacting the districts directly. Because there could be much overlap between the populations

on any individual variable a linear discriminant function will be used. By putting the variables in a linear combination this function maximizes the differences and gives an index number above which success is likely and below which success is improbable. The linear discriminant function also gives the contribution of each of the variables to the final index number. (George W. Davidson)

2159-67067 Marketing. Consumer Expenditure Behavior. Faculty research on consumer expenditure data. Data were purchased from the Bureau of Labor Statistics by the College of Commerce. Various statistical tests will be used in analyzing expenditure behavior. Results will provide a nucleus for articles and other publications in the area of consumer behavior. (R. D. Millican)

2160-67069 T Civil Engineering. Analysis of Hyperboloid Shell for Reactor Containment. An attempt is being made to analyze a structure consisting of a hyperboloid shell with a spherical or ellipsoidal cap, subjected to loadings incidental to operation as a containment building for a nuclear reactor. In the preliminary stages of the investigation, only axially symmetric load states, such as internal pressure and gravity, will be treated, but it is hoped that solutions will ultimately be obtained for such unsymmetric loads as wind, blast and earthquake. The effectiveness of various prestressing schemes will be studied, particularly with respect to the junction between hyperboloid and cap. Finally, attention may be given to shells having variable wall thickness and holes, and subject to thermal stresses. The analysis calls for the solution of a somewhat involved set of simultaneous partial differential equations. Because a closed-form solution would be quite difficult to obtain, numerical methods are being employed. For the axially symmetric cases, the equations become ordinary, and a standard numerical integration procedure using Taylor series and finite differences is contemplated. For the solution of the simultaneous algebraic equations that describe the boundary conditions, an iterative technique will be applied. Use will be made of a modal analysis for

the more involved unsymmetric cases, although an attempt may be made to solve the system entirely by numerical methods. Because of the large amount of routine calculations required in carrying out these numerical schemes, use of a computer provides the only means by which accurate solutions can be obtained in a reasonable amount of time. Consequently, the analysis will depend almost entirely on a computer for its execution. (Garry J. Patterson)

2161-67070 T Special Education. Uses of the Semantic Differential and Modality Differential in Predicting the Recall of Visual-Auditory Integrations. The purpose of the study is to show the integration effects of visual and auditory stimuli on recall, and to see whether or not the modality differential is a better predictor of these effects than the semantic differential. Data were gathered by running 20 subjects individually and making written and tape-recorded records of their responses. Analyses enlisting the aid of the computer are: (1) correlation coefficients for each subject and the total group, showing relationships between recall, modality differential, and semantic differential, and (2) analyses of variance showing the differences in high and low visual and auditory recall. Results will be used to infirm or confirm hypotheses put forth in a master's thesis. (Thomas Nelson)

2162-67071 Institute for Research on Exceptional Children. Symbolic Family Estates. This study is designed to investigate social class differences in kinship structure and the forms of family estates which are passed down from generation to generation. Two kinds of estates will be considered--symbolic and non-symbolic. The focus will be on the symbolic family estates. Symbolic family estates consist of such things as personal biography and access to economic and political institutions by kin. Data on relatives of about 200 families have been collected through interviews with the husbands and wives in these families. Data on about 4,000 relatives will be included in the analysis. The computer will be used to perform factor analysis, multiple regression analysis, discriminate function analysis, and cross-

tabulations and computation of percentages. Approximately 3 hours of machine time will be required over a period of about 15 months. This study is part of a larger project sponsored by the U.S. Office of Education to provide information about communities which will be beneficial to the development of preschool programs for the culturally disadvantaged. Accordingly, the results will be transmitted to developers of educational programs for the culturally disadvantaged and will be reported in sociological journals. (Bernard Farber)

2163-67072 T Department of Computer Science. Phase Shift Oscillators Requiring Minimum Gain Transistors. The problem is to determine the optimal resistor-capacitor tank combination in a phase shift oscillator for a minimum gain transistor. The starting conditions for the phase-shift oscillator are usually expressed for all resistors being equal and all capacitors being equal. Improvement can be expected by properly choosing relative sizes for minimum current loss in the feedback network, using a dimensionless equation with four free variables. Successive approximations with several iterative shcemes will be used. (D. J. Hoffman)

2164-67073 Psychology. Social Motivation in Children. The research deals with social motivation in children and focuses on different reactions of boys and girls to male and female adult experimenters. Reactions of adult males and females to adult and peer male and female experimenters are also under study. The general theoretical position being tested is that in non-evaluative, social situations opposite sex adults are more reinforcing, while in an evaluative situation same-sex adults are more reinforcing. The role of anxiety in these and similar relationships is also being investigated. The computer work to be completed this summer will draw primarily upon SSUPAC programs, especially for correlations and analysis of variance designs. Programs written by the department of psychology consultant will also be used. These programs will be used following standard procedures at the center. (Kennedy Hill)

2165-67074 T Educational Administration. Leadership Behavior of Elementary School Principals. This project is designed to examine the relationship of Executive Professional Leadership, as posited in the National Principalship Study, to factors which may be thought of as its possible determinants, and to other measures of leader behavior utilized in previous research by Andrew Halpin, Fred Fiedler, Charles Bidwell and Egon Guba. Statistical methods utilized include a seventeen variable correlation matrix and a t test for the differences between means of the top and bottom quartile of each variable established through a ranking of mean scores for each principal. Data were obtained from a random sample of twenty-eight elementary school principals in the University of Illinois program of educational administration at a post-master's degree level. The principal and each member of his staff returned two completed instruments which used different criteria for the measurement of the leader behavior of the building principal. The results obtained from the computer will be used to investigate the degree to which correlations between Executive Professional Leadership and some of its possible determinants obtained from elementary principals enrolled in the University of Illinois program of educational administration support findings of the National Principalship study. Computer results obtained from a correlation of Executive Professional Leadership with other measures of leader behavior will also be examined with the purpose of further identifying the nature of Executive Professional Leadership measurement and its implications for administrative training programs and administrators in the field. (David Koch)

2166-67075 Department of Computer Science. Linear Programming for the ILLIAC IV. The object of this effort is to develop logic for a set of general linear programming systems for the planned ILLIAC IV computer. The work will progress in the following sequence: 1. Investigation of techniques to develop inverses of large matrices. Primary consideration will be given to control of truncation errors, pivot strategies, and methods for refinement of an approximate inverse. 2. Investigation of various algorithms for solving the linear programming problem. In addition to

simplex methods, gradient projection and approaches using generalized inverses will be studied. The algorithms will be examined with matrices over a range of sparseness and condition. 3. Development of linear programming coding for the ILLIAC IV. This will be done on the existing computers using simulation programs. Maximum effective use of the parallel structure of the ILLIAC IV and minimum solution time will be of primary importance. Problems formulated with randomly generated coefficients will be used. Structure, sparseness, and the degree of ill-conditioning can be controlled by parameters of the generator. Results will be evaluated to assure correct operation of the program and to measure the effectiveness of an approach in reaching a numerically accurate solution. (J. P. Blondeau)

2167-67076 Department of Computer Science. ILLIAC III Circuit Design. This problem concerns the design of the temperature monitor for ILLIAC III. Over 100 locations will be monitored using thermistors. The specific problem is: 1. To determine the feasibility of using wide tolerance thermistors (inexpensive) and adding a resistor network to each unit in order to achieve a very small tolerance band. 2. If this method is satisfactory, then, to test each thermistor individually, and then calculate the specific resistor network for each thermistor. The actual mathematical procedure involved is fairly simple. No special requirements, subroutines, etc. will be needed. (Newell)

2168-67077 Theoretical and Applied Mechanics. Stress Waves in a Composite Cylinder. This problem involves the solution of a frequency equation resulting from stress waves existing in a composite cylinder. It is necessary to find out how certain parameters, such as frequency, wavelength and wave velocity, depend upon other parameters such as the physical dimensions and material properties of the cylinder. (H. T. Corten)

2169-67078 T Physics. π^o Photoproduction From He^4. This problem replaces 5∅010. (John Staples)

2170-67079 Physics. Intermediate Resonance. This problem replaces 59045. (K. O. Izumo)

2171-67080 T Physics. Bremsstralung Yield Analysis. This problem replaces 33009. (William Switzer)

2172-67081 Physics. Accelerator Design. This problem replaces 66020. (C. S. Robinson)

2173-67082 T Physics. Solid State Detection of Helium From Photoproduction of π^0. This problem replaces 58023. (Marvin Blecher)

2174-67083 T Physics. Proton Compton. This problem replaces 48020. (Edward Gray)

2175-67084 T Physics. Nuclear Reaction Isomer-Ratio Calculation. This problem replaces 2D032. (William Switzer)

2176-67085 T Physics. Monochromator. This problem replaces 47016. (F. Kuchnir)

2177-67086 Physics. Helium Photodisintegration. This problem replaces 32016. (L. Koester)

2178-67087 Physics. Analyses of Decay Spectra. This problem replaces 61010. (M. N. Thompson)

2179-67088 Physics. KO2 Meson Decays. This problem replaces 5N037. (Lynn Verhey)

2180-67089 T Physics. Beam Design. This problem Replaces 62098. (William Hassenzahl)

2181-67090 Physics. K02 Spark Chamber Analysis. This problem replaces 33033. (Dwight Carpenter)

2182-67091 T Physics. KPLUSH. This problem replaces 37004. (R. M. Lansford)

2183-67092 Physics. K Zero Decay. This problem replaces 37019. (A. O. Hanson)

2184-67093 Physics. Pi-Pi and K-K Interactions.. This problem replaces 2∅008. (Ascoli)

2185-67094 Physics. SMP Data Analysis. This problem replaces 63046. (Mortara)

2186-67095 Physics. SMP Data Analysis. This problem replaces 63047. (Mortara)

2187-67096 T Physics. High Energy Physics. This problem replaces 3D018. (Park)

2188-67097 Physics. Development of Bubble Chamber Analysis Programs. This problem replaces 56016. (Ascoli),

2189-67098 Engineering Administration. Engineering College Research and Record Analysis. The College of Engineering is presently contacting companies throughout Illinois to increase technical interaction. Presently the problem is to retrieve from other type sources a listing of such firms by various manufacturing and production types. Later this information will be coupled with additional information to provide a basis for increasing technical interaction in research and development areas. (Marvin Krasnow)

2190-67100 Department of Computer Science. Simulation of ILLIAC III Arithmetic Unit. The IBM 7094 will be used to assist in the design of the arithmetic unit of the Illinois Pattern Recognition Computer (ILLIAC III). Initially, it will be used to test new algorithms for performing digital arithmetic. The selected algorithms will then be incorporated in a model of the complete arithmetic unit: the model will serve as a basis for hardware implementation and as a standard in subsequent debugging of the hardware device. (D. E. Atkins)

2191-67101 T Agronomy. Crop Yield Trends in Illinois, 1931-1965. The objective of the study is to investigate crop yield trends of corn, soybeans, wheat, and oats in Illinois for the period 1931-1965. A regression equation will be determined for several soil series in Illinois. For each field of a given farm, information will be obtained by using individual farm records. The computer will be used first to plot the data to indicate the general relationship between each variable and yield, and then to perform the curvilinear regression analysis. The regression will be used to study the relationships between the variables and yield, and also, the relationships among the variables. The regression equations obtained will be useful in predicting yields under different systems of management and weather regimes. Regression equations from experiment fields, crop reporting districts, and individual farms will be compared to study any differences that may occur. (Frazee)

2192-67102 Civil Engineering. Yield Surfaces and Load Functions for Doubly Symmetric Sections. This problem is the first phase in the development of a general limit analysis procedure. Yield surface expressions are derived for four different cross-sections, using a procedure developed for determining the yield surface corresponding to any given stress resultant vector. The load factor corresponding to formation of a plastic hinge is obtained using the Newton-Raphson method. Load factors are calculated for a representative series of stress resultant vectors. (G. Morris)

2193-67103 T Civil Engineering. Inelastic Analysis of Slope Stability by the Finite Element Method. For various assumed physical properties of earth materials, an analysis will be made to determine the stress distribution in a slope. The state of stress will vary in both the elastic and the plastic ranges. The method of analysis will be the finite element method of structural analysis used for a continuum. From the stress distribution it is anticipated that some rational evaluations of slope stability in such materials will be able to be made. Applications of such a method of analysis will be in the fields of soil and rock mechanics, structural geology, and open-pit mining. Data will be assummed physical properties and geometry. (Richard Gates)

2194-67104 Physics. Program Maintenance-Bubble Chamber Group. The various programmers working on the development of programs for analysis of bubble chamber film will be consolidated into one group. This group will then consist of people now working under 2Ø008, 56016, 3D018, 63046, 63047, and 67027. Such a centralized group should reduce duplication of effort. (Scharf)

2195-67106 Psychology. Assessment and Change of Emotional Behavior. The computer will be used to obtain intercorrelations, means, and standard deviations among physiological, test, and observation data concerning emotional behavior. The data were obtained from several groups of anxious subjects taking part in a study of psychotherapy and emotional re-training at points before, during, and after treatment. The intercorrelations will provide data on the predictibility of change and the reliability and stability of assessment. Means and standard deviations will be subjected to further analysis, and used to check analyses already completed or between group differences. (Gordon L. Paul)

2196-67107 Material Research Laboratory. Anharmonicity in Metals. The computer will be employed to study properties of metals with particular emphasis on those properties arising from the anharmonicity of "atomic oscillators". In particular, experimental data will be used for least squares fitting, and the computer will be used to calculate tables of theoretical functions arising in connection with this problem. (A. V. Granato)

2197-67108 T Material Research Laboratory. Thermo Electric Power of Metals. The problem is to determine the effect of pressure on the thermal electric power (TEP) of metals. The computer will be given points x_i and y_i and be asked to fit them to a polynomial and take the slope. The library program LSQ3 will be used. The points x_i and y_i correspond to the temperature and thermal EMF, respectively, of the particular metal at a given pressure. The data are the output of a two channel strip chart recorder. The slope of this curve is the thermoelectric power of the metal as a function of temperature at the given pressure. (Ron Bourassa)

2198-67109 T Speech and Theatre. A Study of Normal Hearing Children's Discrimination Ability for Two Types of Verbal Materials Presented with Varying Degrees of Distortion. This study was designed to compare discrimination abilities of normal hearing children for a restricted-choice vs. an open-choice auditory discrimination word list recorded with varying degrees of frequency translation with and without time restoration. Analyses to be computed are between materials, across types and degrees of frequency and time distortion, and interactions of these factors. Correlations are also to be determined between discrimination scores for these listening conditions and vocabulary recognition scores. Subjects were 496 second grade school children divided into two control and eighteen experimental groups. The data are expected to have application for speech and language learning for high-frequency hearing-loss populations. (Harold A. Peterson)

2199-68001 T Educational Administration. Exploration of Effects of State Impaction on Financing Schools. While most experts in school finance agree that large concentrations of state owned property in a school district (i.e., state impaction) will adversely effect its finances, this effect has yet to be demonstrated by studies conducted in the field. The present exploration is designed to identify the specific effects of state impaction, if any, through trend comparisons between groups of randomly selected school districts with differing proportions of state impaction over a twelve year span of time from 1952 to 1964. The data to be analyzed will be organized in a 4x5 matrix containing four groups of differing degrees of impaction as the trend factors and five years (1952, 1955, 1958, 1961, and 1964) as the control factors. Each of the nine financial factors to be studied will require seven two-way

analyses of variance, an overall analysis of the entire matrix, and six analyses for the six possible comparisons between the four trend lines included in each overall analysis. For ease of interpretation, the four trend lines will be presented graphically in the body of the thesis for each of the financial factors for which the F test is significant in the overall analysis. (Gary A. Blade)

2200-68002 T Admissions and Records. Relation of Student Persistence in College to Satisfaction with Adaptive Factors. After a period of time students of a selected college class may be categorized as those who persisted, those who left for required (academic and displinary) reasons, and those who left for nonrequired reasons. The problem is to relate students' attitudes, judgments, and perceptions to persistence in college. The computer will be utilized to relate the data gathered by the use of a Student Information Form which the students completed during their second semester of attendance to their status six semesters later. Chi-square, factor analysis, analysis of variance, and discriminant analysis techniques will be employed to examine the relationship between persisting or leaving and students' evaluation of certain aspects of the University of Illinois. The computer results will be used as a basis for recommendations designed to reduce attrition at the University of Illinois. (L. F. Robinson)

2201-68003 Geography. Manufacturing Productivity. This project is concerned with the spatial variation of the productivity of labor in manufacturing industries. Specifically it is concerned with the variance displayed by the states in 1958 in each of 15 two-digit industries as defined and reported in the 1958 Census of Manufactures. A step-wise correlation model is used. Input data have been obtained from the above census. The output will be used to test the hypothesis that the independent variables provide a valid explanation of spatial variation in labor productivity in manufacturing. (Roepke)

2202-68004 Nuclear Engineering. Ribbed Slab Shielding. This project will study radiation shielding by "ribbed" slabs. Part of the study involves the exact calculation of radiation transport by "Monte Carlo" techniques on the computer. After these results are obtained, approximate,

simplified methods will be devised in which the ribs are considered as perturbations on the radiation penetration of a simple slab. These results will be checked against the Monte Carlo results until assured that the simple mathematical model is adequate for the purpose. Then production of data with variation of input parameters will be carried out. (A. B. Chilton)

2203-68005 T Vocational and Technical Education. Working Wives. The main objective of this study was to ascertain the attitudes of married male graduate students with children, married male graduate students without children, and unmarried male graduate students at the University of Arizona toward the employment of their wives during five stages in the family life cycle in careers or at "just jobs." The data were obtained through questionnaires. They will be analyzed by use of the Friedman two-way analysis of variance by ranks, by the computation of gamma, and by use of the Kolmogorov-Smirnov two-sample one-tailed test. (Doris E. Manning)

2204-68006 T Education. Test of the Interrelationships of Treatments and Variables in Affecting Appreciation. This research examines the relationships between five methods of treatment and the variables of sex, intelligence, maturation, achievement, academic self-concept, parental education, health, and attitude toward the subject to determine the feasibility of matching students with a particular treatment to maximize effective learning. The population consists of nine hundred eighth grade students. These students were exposed to five treatments, approximately one-fifth of the population per treatment; each treatment was designed to promote in a different way the students' ability in judging lyric poetry. Pre-tests and post-tests were given, and the data on the variables were gathered during the spring semester of the public school year 1965-66.

Through variance analysis of the data the specific combinations of variables and treatments yielding the greatest positive score improvements can be determined. Due to the very large number of combinations in the design simple correlations will be produced to aid in the selection of the general combinations which appear most interesting.

The results of such an analysis will be instrumental in judging the pedegogical value of specific grouping formulae now employed widely in secondary education. They should also throw light on the possibility of individulizing educational programs to make maximum use of pupil and teacher

time. While the subject tested in this research is only one of many possible concerns of an English classroom teacher, the nature of the subject, literary appreciation or aesthetic valuation, as well as the classical nature of the treatments raise the possibility of hueristic value of this analysis for other areas of the English curriculum as well as those logical extensions in the fine arts. (John E. Erickson)

2205-68007 Chemistry and Chemical Engineering. Rate of Racemization. This is an investigation of the mechanism of racemization of d-pyruvic acid oximato-bis(2,2'-bi-pyridine)-cobalt(III) nitrate, followed by polarimetric measurements. The technique is to solve for a set $\{k(i)\}$ which corresponds to sets $\{a_t(i)\}$ and $\{t(i)\}$ by means of the equation

$$k = \frac{1}{t} \ln (a_0 - a_{10}/a_t - a_{10}$$

where a_0 and a_{10} are constants. The program will read values of t and a_t, and will solve and print out k for each set of t and a_t. (J. C. Bailar, Jr.)

2206-68011 Agricultural Engineering. Dynamics of Machines II. The objective of the project is to determine the influence of the various design and operating parameters on the performance of agricultural prime movers. A mathematical model characterizing a tractor operating over varying terrain with eleven degrees of freedom is being developed, and the ensuing system of differential equations will be solved using Runge-Kutta techniques. The goal will be to relate center of gravity, tire spring and damping characteristics, moments of inertia, and geometry of a tractor for more stable and safe operation on side slopes containing bumps and other irregularities. (Roger R. Yoerger)

2207-68012 Chemistry and Chemical Engineering. Reaction Rates in Critical Solutions. A solution in the vicinity of a second-order phase transition, i.e., a liquid-liquid consolute point or a liquid-vapor critical point, exhibits anomalous thermodynamic and transport properties. The heat capacity and viscosity become very large, the diffusivity extremely small. Fluctuations of molecular density and energy become enormous. This research proposes the investigation of reaction rates in the vicinity of such critical points. Computer time is required for this project for two purposes. First, a fair amount of time is needed to reduce the experimental data. One of the experimental techniques being used involves an indirect measurement of reaction and the calculation for each data point requires the simultaneous solution of ten nonlinear equations by a multiple iteration technique. Although this requires only a few seconds for each data point, the number of data to be evaluated will run into the thousands. The second use of computer time will be the calculation of theoretical models for comparison with the data. This will involve statistical mechanical calculations of properties from pair distribution functions for dense fluids and will include an attempt to account for the order-disorder effect near the critical point. (C. A. Eckert)

2208-68013 Agricultural Engineering. Distributing Drainage Assessments. The objective of this project is to formulate an assessment procedure for drainage districts based upon the measurable physical features of the land. An equation has been formulated using the physical features that control drainage as the parameters which will predict relative benefits from drainage. A multiple regression analysis will be used to predict the constants in the equation using data measured from drainage districts already in existence. (Richard Bengtson)

2209-68014 T Zoology. Bioenergetics and Lipid Utilization of Animals. Studies of various vertebrate and invertebrate animals are being undertaken to elucidate the animals' capacity to survive under different degrees of environmental stress and thus to inhabit different climates. Of major concern is the investigation of the animals' energy storage and expenditure at different temperatures. Regression lines will be computed for metabolic rate versus environmental temperature and regression significance calculated by analysis of variance. With some organisms, multiple correlations,

involving metabolic rate, temperature, relative humidity, and/or photoperiod will be computed. Also, since lipids are the major forms of energy storage, analyses of variance of various lipid components of the animals will be performed to ascertain the influence of such energy reserves on the animals' capacity to adapt to environmental stress. (Jerrold H. Zar)

2210-68015 T Electrical Engineering. Cavity Slot Array. This research problem involves the investigation of a log-periodic cavity-backed slot array to be used as a flush-mounted broadband antenna. A mathematical model of the antenna has been developed and, by using experimental data obtained for a single cell of this antenna, a complete analysis may be obtained for this antenna. Parameter variations will be studied and, hopefully, optimum design characteristics will be found. The computer will be used to perform several numeric integrations and to solve a set of linear simultaneous complex equations. The solution to these simultaneous equations will then be used to determine the input impedance of the antenna and, with a few more computer calculations, the far-field radiation pattern of the antenna. The entire procedure will then be repeated for any number of desired frequencies. (V. A. Mikenas)

2211-68016 T Civil Engineering. A Markov-chain Model for the Reliability Analysis of Indeterminate Structures. The safety analysis of indeterminate structures of general geometrical and topological makeup can be formulated by means of a Markov-chain model. In this context the state-space of the chain is represented by the degrees of redundancy of the structure. Based on the single assumption that the decrease of the number of degrees of indeterminacy of the structure takes place by the failure of only one member at a time, an approximate transition probability matrix can be obtained. The method will be applied to the safety analysis of typical structural systems. (Jorge Ishizawa)

2212-68021 Bureau of Institutional Research. Bureau of Institutional Research Grade Study. This is an administrative study investigating various relationships between students' grades at the University and selected biographic characteristics of the students. (John Terwilliger)

2213-68022 Theoretical and Applied Mechanics. Control of Concrete Cracking. An investigation of the parameters which affect the propagation of cracks in concrete is being conducted. In connection with this investigation, it is desired to determine the analytical stress distribution in a concrete specimen containing a single reinforcing bar which is loaded in axial tension. The stresses in the body can be found from the Airy stress function, ϕ, which must satisfy the biharmonic equation,

$$\frac{\partial^4 \phi}{\partial x^4} + \frac{\partial^4 \phi}{\partial x^2 \partial y^2} + \frac{\partial^4 \phi}{\partial y^4} = 0$$

for a two-dimensional body with zero or constant body forces. The computer will be used to solve the biharmonic equation for numerical values of the Airy stress function by the method of finite differences and successive approximations. The program is designed to permit input of various values of boundary conditions, body geometry, and material properties, so that a wide range of solutions may be obtained. The results of this analytical study will be compared to previous analytical studies and to a concurrent experimental investigation. A portion of the computer time will be used to process data from the experimental investigation. (David Raecke)

2214-68023 Electrical Engineering. Wave Growth on Accelerated Jets. An electric field normal to the surface of a thin conducting liquid jet will cause spatial instability of the kink mode. When the jet is accelerated in its direction of flow, the growth rate of this instability cannot be described by a simple dispersion relation because the equation of motion contains variable coefficients. In this work, the growth of waves on an accelerated jet will be studied by: (a) numerical solution of the equation of motion, (b) a perturbation expansion in the acceleration, (c) an average growth rate calculated using the local growth rate at various points along the jet. The computer will be used to solve the equation of motion numerically and to evaluate the perturbation expansion and the average growth rates. (Crowley)

2215-68024 T Agricultural Economics. Cooperative Extension Service County Council Members: Their Characteristics, Knowledge, and Attitudes. The problem is to determine the various responses to personal interviews with agricultural and home economics extension council members in six randomly selected counties. The survey was to find what selected characteristics of those members were, and how well they knew their jobs or duties as council members (role knowledge) in their role performance as council members and in the various groups in the community and in their attitudes toward the county extension program. This problem will find the total number of each type of response and also will run T-tests to find out the relationship between the various personal characteristics and (1) their total knowledge score, (2) their role performance, both as council members and in the community, and (3) their attitudes toward the extension programs. (Wayne H. Oberle)

2216-68028 Children's Research Center. Behavior Traits Analysis. This project is a statistical analysis of behavior traits of children (mentally retarded, emotionally disturbed, and normal). Techniques such as factor analysis, multiple correlation, canonical correlation, and analysis of variance will be employed. Areas concerned are psychology, psychiatry, and special education. (H. C. Quay)

2217-68029 Institute for Research on Exceptional Children. Preschool Program for Disadvantaged Children. This project is designed as a five-year longitudinal study of the remediational effects of a highly structured preschool program on the intellectual, linguistic, perceptual, and vocabulary development of culturally disadvantaged children. The data gathered for analysis were obtained through a pre- and post-test evaluation of the subjects utilizing psychological scales of intellectual functioning, psycholinguistic abilities, perceptual development, vocabulary development, and general school readiness. The facilities of the Department of Computer Science lend themselves to a more efficient analysis of the data because of the cumulative nature of the data, the number of variables, and the number of statistical analyses planned. The initial analysis planned entails the application of t-tests. (Dr. Karnes)

2218-69001 T Psychology. The Move Study. The project capitalized on a move of psychiatric patients from an old, outdated facility to a new facility. Contrasted with the group which moved was a control group of patients which remained in the old building. In addition, responsibility for the move was given to a subgroup of patients who were moved. The hypotheses concerned the effect of the move and move-responsibility on the pathology level of the patients as recorded by three measures from three different sources (an "objective observer," personnel on the ward, and patients). The three measures were obtained for each patient three times: one pre-move measure and two post-move measures. Various analyses of variance for repeated measures will be performed on the computer to investigate the effects of the move and responsibility. Also various t-tests for significance will be performed in order to detect effects on each of the treatment groups at each time interval. Finally, factor analyses are desired on each of the three measures in an effort to make the measures more economical for future use. (David L. Devries)

2219-69003 Health Education. An analysis of Smoking Attitudes and Habits of High School Students. The purpose of this project is to attempt to establish differences in attitudes and behavior between smokers and non-smokers at the high school level. A 100-item survey on attitudes and behavior was administered to 300 high school students at Champaign High School Annex. The t-test for difference between means will be used to determine whether or not the items on the Survey are discriminating between the smoker and the non-smoker. This is a pilot survey taken this summer to see if the questionnaire actually does differentiate between the smoker and non-smoker. A larger survey will be conducted in the fall. (D. B. Stone)

2220-69004 Department of Computer Science. Threshold Logic ILP-1. The problem is to find the optimum threshold network for Boolean functions. Synthesis methods based on integer linear programming will be studied for this purpose. The computer will be used in solving properly formulated integer linear programming. (Saburo Muroga)

2221-69005 Theoretical and Applied Mechanics. Brittle Fracture of Structural Steel. This is a study of the crack toughness of structural steel. In order to calculate the toughness, a plot of the compliance of the specimen versus crack length is required. Data points can be generated by introducing different crack lengths; however, an analytical expression for the curve through these points is necessary. Least squares techniques are used to derive an analytical expression in the form of a polynomial of degree seven or less. This polynomial expresses the compliance as a function of the crack length. It is differentiated and used to calculate the crack toughness. (H. T. Corten)

2222-69006 Psychology. National Science Foundation Factor Analytic Student Research. Five potential new dimensions of personality, beyond the original sixteen personality factors, have been proposed. The purpose of the present research is the extension, analysis, and validation of these personality factors. Self-administered test packets from a sample of three hundred teachers and students at the University of Illinois were gathered this summer. The computer will be used in the scoring of these tests and in correlational and factor analysis of the resulting scores. Because of the factors under present scrutiny have been derived from a sample of questions specifically designed to discriminate between normal individuals and individuals with various types of pathological personalities, it is expected that they will give future researchers insight into the nature of "abnormality." (L. Specht)

2223-69010 Mechanical Engineering. Gear Design and Appraisal. This problem will involve combining the strength, wear, and scoring criteria associated with spur gears into a computer program that will enable the user to design spur gears. The completed program will be used to supplement lecture presentations in machine design courses. (D. H. Offner)

2224-69011 T Chemistry and Chemical Engineering. Flow Around a Cylinder. It is proposed to solve the Navier-Stokes equations numerically for the case of flow of fluid around a circular cylinder. The equations are solved in the form

$$\nabla^2\zeta = R/2 \left(\frac{\partial\psi}{\partial\eta}\frac{\partial\zeta}{\partial\xi} - \frac{\partial\psi}{\partial\xi}\frac{\partial\zeta}{\partial\eta}\right)$$

$$\nabla^2\psi = \zeta$$

The partial derivatives are replaced by finite difference approximations and the resulting equations solved for ψ and ζ by successive optimum displacements by points. Values of ψ and ζ obtained are plotted and lines are drawn through points on the grid having equal values of ψ. These represent the streamlines. Similarly lines are drawn through points of equal ζ, and these represent the vorticity distribution in the flow field. (Jaime Santos Son)

2225-69012 T Animal Science. Endocrine Studies. Recent evidence suggests that the brain and hypotholamic centers are involved in the release of luteinizing hormone. Factors which influence and control this release from the pituitary gland are being studied in the rat and the chicken. A principal method is biological assay of the amount of hormone in the blood plasma, as associated with stage of the estrual cycle (rat) or of the laying or ovulatory cyle (hen). Individual biological assays use a standard six-point design which is analyzed by the method of least squares. The computer will be used to analyze the data for individual biological assays, and to analyze data from experiments designed to ascertain the influential factors in release of luteinizing hormone from the pituitary gland, in which the data are the results of individual biological assays. (A. V. Nalbandov)

2226-69013 T Chemistry and Chemical Engineering. Extended Hückel Calculations and First Order Rate Data. The Extended Hückel Treatment will be used to correlate and predict the course of a number of ground and excited state unimolecular reactions. Rate data pertinent to this problem will also be processed. This method requires matrix diagnoli-zations and least squares calculations. (James Lee)

2227-69014 Chemistry and Chemical Engineering. Computer Processing of Mass Spectra Data (II). The computer will be used to normalize and compute % total ionization of mass spectra data. The input data for the computer will be obtained from the ATLAS CH4 mass spectrometer. The computer results will be used for interpretation of molecular structure. (R. H. Suzuki)

2228-69016 Chemistry and Chemical Engineering. Numerical Analysis of Data and Models. In a variety of mechanistic studies of organic chemical reactions, crude experimental data (such as kinetic data expressing reaction velocity as a function of time and other variables) must be manipulated through standard numerical analytical techniques before its significance and import can be assessed. Alternately, mathematical models of a reaction or of the functional dependence between a physical property and molecular structure need to be treated numerically before their suitability can be gauged. The computer will be used for such numerical computations, designed to aid investigations of the interrelations between chemical reactivity, physical properties, and molecular structure. (J. E. Baldwin)

2229-69017 Office of Instructional Resources. The Improvement of College Level Student Achievement Through Changes in Classroom Examination Procedures. The purpose of this research is to determine the extent of the relationship between examining and learning, to assess the degree to which alterations in the examination system can serve to correspondingly affect learning, and to determine those characteristics of examining procedures which may lead to more satisfactory levels of student achievement. It is hypothesized in this research that the type of examination system used in an educational program represents to a considerable degree the ultimate objectives of that learning system. Thus, examinations serve to direct, influence, and determine what is learned even, to some extent, regardless of stated educational objectives. Because this project requires the scoring and analysis of large numbers of tests, the use of optical reading systems and computer facilities is necessary. Software, in the forms of test scoring and item analysis programs, has already been developed. The statistical techniques of correlation, analysis of variance, analysis of covariance, t-tests, multiple correlation, and factor analysis will be employed. Randomized groups of students under similar instructional procedures will be presented differing examination models and systems, varying in such characteristics as number of tests, type of test item (essay or multiple choice), and length of tests. Conclusions will be drawn relative to an analysis of the role of examinations in college level learning, and to which degree learning of various types may be affected by variations in examination procedures. (Richard E. Spencer)

2230-69018 T Agricultural Engineering. Swine Housing Environment. An experiment will be conducted in the laboratory to determine the rate and efficiency at which livestock wastes can be decomposed by aerobic organisms. The data will concern the amount of nutrients used by microorganisms per unit time as well as the amount of organic matter oxidized per unit time. These quantities can be found with chemical measurements in the laboratory. The computer will be used to analyze experimental data using appropriate constants and statistical methods. It will also be used to plot curves to find trends in the data with time. (Don D. Jones)

2231-69019 T Geology. Structural and Chemical Analyses of Illites. The problem is the analysis of data obtained following laboratory treatment of samples of the clay mineral illite with solutions of varying concentrations of H_3BO_3 and varying concentrations of $CaCl_2$ at different temperatures, pressures, and times of treatment. These data will be of two principal types which will require two different methods of analysis: (1) Preceding and following the chemical treatment, chemical analyses for boron will be made on the clays to determine the amount of boron sorbed by the illite during the various treatments. It is planned to use the 7094 for statistical analysis of these data. Specifically, it is planned to make a 4-dimensional analysis of variance study of the data, utilizing calculated first and second moments and the F distribution. In addition, chi-squared, t-, covariance, correlation, and multiple regression analyses will be made on various samples. (2) Preceding and following chemical treatment, oriented aggregates of the samples will be analyzed by x-ray diffraction. It is planned to use the 7094 to analyze diffraction intensity data so obtained using a one-dimensional Fourier synthesis. The resulting models will then be compared to various theoretical models, also generated by one-dimensional Fourier synthesis, to evaluate structural changes in the clay mineral as a result of substitution of boron for silicon and/or aluminum. (Elton L. Couch)

2232-69027 T Chemistry and Chemical Engineering. Vinylcyclopropane Molecular Orbitals. The symmetry and relative energy of the highest filled extended-Hückel molecular orbital of vinylcyclopropane are being investigated. The Woodward-Hoffmann criterion will be used to predict the stereochemical course of the thermal isomerization of vinylcyclopropane to cyclopentene. (P. M. Harvey)

2233-69028 Health Service. Swimming Pool Turbidity. Approximately 750 samples collected from 100 swimming pools in east central Illinois have been analyzed for turbidity (non-clarity). The turbidity was measured with a light scattering device called a nephelometer. Information on the size of the pool, number of swimmers, bacterial analysis, ownership, location of sampling point, pH, temperature, and chlorine residual are available. An attempt will be made through the use of the computer to correlate the turbidity with one or more of these variables. First, averages, frequency distributions and standard deviations will be computed for the turbidity analyses as a whole and by groupings such as ownership, indoor-outdoor pools, type of filtration systems, etc. After this, an attempt will be made to link the turbidity with some of the operational data such as pool loads, chlorine residual, etc., by means of linear or multiple correlations. The results will first of all give an overall picture of the clarity of public swimming pool water in terms of turbidity. Also, the study will point out which type of pool is expected to have the clearest water. Third, the study will hopefully correlate operational data with the pool water turbidity. (Henry Koertge)

2234-69031 Mechanical Engineering. Calculation for Gas Dynamics Lab. The development of new facilities and improvement of existing equipment requires knowledge of the fluid flow field as well as heat transfer characteristics and forces imposed on the equipment. Computer programs utilizing the method of characteristics for supersonic flows and numerical techniques for calculating heat transfer and forces are to be utilized in this program of uprating the Gas Dynamics Laboratory and implementing the new laboratory. (Robert A. White)

2235-69055 Materials Research Laboratory. Raman Spectroscopy of Defects in Alkali Halide Crystals. The general problem under consideration is the use of Raman spectroscopy to study defects in alkali-halide crystals with particular emphasis on the OH^- center. In this study the computer will be utilized in the following ways: (1) In the design and evaluation of the optical components to be used in the experimental apparatus, employing the laws of geometrical optics in various ray-tracing programs; (2) In the analysis of raw experimental data which will possibly include the use of signal averaging techniques to improve signal to noise ratio; (3) In the formulation and evaluation of methematical models to describe and explain the experimental results and in the performance of calculations based on such models. (M. V. Klein)

2236-69056 Institute of Government and Public Affairs. Financing Illinois Government. The problem is to analyze revenue and expenditure data of the State of Illinois. Data will be obtained from the U. S. Census Bureau and state financial reports. Tax elasticity coefficients will be computed and multiple regression analysis will be used to project state expenditure and revenue yields. (Glenn W. Fisher)

2237-69057 Psychology. National Science Foundation Student Research. The overall problem for which the computer will be used is the Department of Psychology National Science Foundation Undergraduate Research Participation Program. The data to be analyzed are collected by the undergraduate research participants in the program under the supervision of a staff member. Some of the data come from animal research and other data from human research. The mathematical methods which will be used are quite varied since the students are working on individual projects in diverse areas of psychological research. The most frequently used statistical analyses in the past have been factor analysis, correlational analyses, analysis of variance, and chi-square analysis. Most of the computer programs required for the research are supplied by SSUPAC. Department of Psychology programmers are available for whatever additional computer programs are needed. (Kennedy Hill)

2238-69058 Psychology. Tree Structure Analysis. The computer will be used for a so-called 'tree-structure analysis' of psycholinguistic data. Tree-structure analysis is designed to represent similarities or strengths of relations between objects by partitioning these objects in groups and subgroups. Groupings of this sort are representable by way of tree graphs; the terminal elements represent the individual objects and the form of the tree indicates how these objects are partitioned in more and more inclusive sets. For this study the objects can be either words of a sentence or independent words. In the former case the result of the analysis is a phrase marker representing the structure of the sentence; in the latter case the tree is a hierarchical representation of the semantic features that determine the meaning of the independent words. The mathematical method used is Johnson's hierarchical clustering algorithm. It is designed to map a symmetrical similarity matrix onto a tree graph. Representations obtained

in this way will be compared with more conventional spatial representations as obtained by factor analysis and by Shepard's multidimensional scaling program. Data are obtained by (1) having subjects judge the relatedness of all the word pairs from a sentence, or (2) by having subjects judge the similarity in meaning for all pairs of words from a set of words. These are done either by magnitude estimation or by triadic comparisons. The results of this analysis will be used to increase insight in the possible psychological reality of linguistic quantities and relations. (W. J. Levelt)

2239-69059 T Civil Engineering. Free and Forced Vibrations of Shells of Revolution. The free and forced vibrations of shells of revolution are investigated with special attention given to hyperboloids subjected to wind loading. The asymptotic method is used to solve the governing differential equations for the natural frequencies and mode shapes. From these the elastic response due to dynamic loading is determined by using a model method of analysis. (R. L. Carter)

2240-69060 Agronomy. Employment of Agronomists. In order to keep abreast of the employment of agronomists, yearly information is obtained relative to the placement of graduating agronomists. Fifty-seven employment classifications are considered which break down into fourteen general employment areas such as agriculture business, farming, services, graduate school, etc. Due to an increasing number of foreign students, the employment information is recorded separately for domestic and foreign students. Approximately 20% of all agronomy graduates are foreign students. The above information is taken for each of the three degrees (B.S., M.S., and Ph.D.), and the computer is used to summarize the information in the most meaningful ways. This can be done for individual years and any combination of years for which the data are available. This information was first collected for the school year 1957-58 and has been collected for each succeeding school year. (Seif)

2241-69061 Civil Engineering. A Program for Detailing Steel Frames. A program has been devised that accepts as input information transcribed from typical engineering elevation and assembly drawings of structural steel frames, and outputs sufficient information to describe the fabrication

details (holes and copes) of the individual members of the frames. This output may be in printed form, or card decks to be used as input to "post-processor" programs that control drafting machines or numerically controlled machine tools. The program operates by combining proper information from several files. In addition, a new post-processor program will be developed to generate detail drawings on the CalComp plotter from the information output by the main program. (F. Hatfield)

2242-69069 T Theoretical and Applied Mechanics. Impedances of a Pulsatile Flexible Model of a Circle of Willis. This work is to be one of the final steps in the development of an engineering model of a portion of the blood distribution system of mammals. A rubber model of the arteries of this portion (the circle of Willis) has been fabricated. This study is to predict fluid pressures and flows corresponding to different terminal conditions, which will simulate certain physiological conditions. Experimental comparison of the predictions will then be made in the hope that the analytical phase can be extended to include conditions that are difficult to realize experimentally. It will be necessary to solve simultaneous equations that contain complex quantities. There will be as many as twenty equations, each having ten complex terms (not all unknown) and about 15 real terms. (Mike Roller)

2243-69070 T Theoretical and Applied Mechanics. Evaluation of Wave Motion Equations. The purpose of this research is to establish dynamic scattered light photoelasticity. The problem studied is the stress distribution, due to an explosive load at the free surface, in a semi-infinite space. The computer will be used to evaluate two polynomials in space and time. The computer data will then be compared to experimental data. The polynomials are the analytical solution to a wave motion problem. (John Hemann)

2244-69072 T Graduate School of Business Administration. Critical Path Scheduling Under Limited Resources. This research is to construct and test models for the allocation of limited resources to a critical path scheduling situation. The models for such problems are sufficiently complicated that

it is necessary to use a large-scale computer for testing these models efficiently. In this research, some use will be made of standard programs, such as linear programming algorithms; and additional programs will be written for the algorithms developed in the research. (Rich Burton)

2245-69076 T Mechanical Engineering. Transient Diffusion Flame Phenomena. This research problem consists of an analytical and experimental investigation of the high pressure spray characteristics, fuel air mixing, and diffusion flame phenomena in a highly turbo-charged pre-chamber compression ignition engine. The detailed analysis of the high-speed compression ignition considers the effects of dissociation, finite reaction kinetics, and irreversibilities such as heat transfer and mechanical friction on cycle performance and efficiency, and provides a highly flexible tool for investigating the complex relationships among engine variables. The resulting mathematical model and the related computer program offer a substantial computational advantage over previous methods that employ charts and graphs and require a large amount of manual calculations. The computer will be used for data reduction and analysis of combustion phenomena. (E. K. Buchholz)

2246-69077 Mechanical Engineering. Minor Problems in Electrohydrodynamic Flow. The time requested will be used for short computational problems in electrohydrodynamic flow. Typical problems requiring computer solution will include least squares fits for experimental data, repetitive calculation and tabulation of simple theoretical formulas, and other problems of this nature. The particular areas of interest will include (1) particulate flow between parallel plates, (2) interactions between two streams containing particulate matter, and (3) ionized gases. (S. L. Soo)

2247-69078 T Theoretical and Applied Mechanics. Concrete Beam Reinforced With High Strength Steel. The computer will be used in this problem by making successive approximations of mathematical data in order to determine the maximum moment which can be resisted by a concrete beam reinforced with high strength steel or by a metal with a generalized stress-strain curve.

A theoretical stress-strain equation for concrete will be used. The main function of the computer will be to establish relationships between steel stress and concrete strain for varying concrete strengths and percentages of steel reinforcement. (Peter D. Heimdahl)

2248-69079 Institute of Communications Research. Attitude-Behavior Relationships. This project is concerned with investigating the relationships between beliefs, attitudes, behavior intentions, and overt behavior in both field and laboratory situations. Various types of statistical analyses will be required for different portions of the overall project; included among these are: multiple discriminant function analyses, two and three-mode factor analyses, and complex analysis of variance designs. Approximately one-half of the data have been gathered using various interview schedules in the Champaign-Urbana community, and the remaining data have been gathered in laboratory experiments. (Fishbein)

2249-69080 Vocational and Technical Education. Work-Education Research Project. This study contains two interrelated parts: (a) a descriptive study of the conduct of concurrent work-education programs, and (b) an in-depth study of the consequences of concurrent work-education programs at selected sites. The first phase (part (a) above) will determine the number of students enrolled, student characteristics, school characteristics, work-station assignments, and other factors pertinent to an accurate description of concurrent work-education programs in public high schools and junior colleges in the United States. The second phase (part (b) above) will study in depth characteristics of students and programs at approximately thirty schools, selected on the basis of data collected in phase one.

Data will be collected in six regional centers for their respective geographical areas. The data will then be sent to the project office on the University of Illinois campus for compilation, processing and analysis. The project office here will coordinate all the activities in the six regional offices. It is estimated that approximately 30,000 IBM cards will need to be punched and verified. Existing computer programs - either SSUPAC or BIMED from the University of California Los Angeles Health Sciences Computing Center - will be used in the statistical analysis.

In Phase One, most of the data are quantitative and consequently can be reported in raw form with measures of central tendency. Comparisons of frequencies will be made with chi-square. In Phase Two, it is anticipated that the parameters of all variables will be such that nonparametric statistics will have to be used. Therefore, chi-square, Kruskal-Wallis, and the sign test will be used. If parameters and distribution permit, discriminant analysis will be used. (W. J. Schill)

2250-69081 Botany. Difference Band Analysis. The chlorophyll _a_ fluoresence emission band of the alga _chlorella pyrenoidosa_ is a composite of two overlapping fluoresence bands corresponding to two slightly different forms of chlorophyll _a_. The relative amounts of the two forms are determined by the wavelength of light used to excite the emission. The shape of the individual bands is known, to a good approximation, from another source, but the wavelengths of their emission maxima are unknown. The analysis is performed by use of a method analagous to that used to solve simultaneous equations. Two sets of data points, corresponding to excitation at two different wavelengths, are used. One set is multiplied by a series of constants. The difference between the two sets is computed, and the resulting series of "difference bands" compared to the known shape of the chlorophyll _a_ emission band, until the best fit is obtained. The same process is then repeated, reversing the roles of the two sets, and the best fit again found. The two best fits arrived at correspond to the two unknown components of the complex band. (Williams)

2251-69082 Curriculum Laboratory. Analysis of Teacher-Held Objectives. This project involves an analysis of student performance on University of Illinois Committee on School Mathematics materials based on a categorization in terms of teacher-held objectives. Student scores on mathematics tests will be analyzed by covariance and multiple discriminant function techniques. (Kraatz)

2252-69083 Industrial Administration. Organization Analysis. This project is interested in obtaining optimum strategies for the control of organizational activities. Each of these activities is represented by one of a finite number of performance states. The manager in charge of these activities is interested in knowing an optimum frequency of collecting information regarding the states of the activities and, with this information, an optimum control action necessary for each of the activities. The optimum solutions regarding the frequency and control action are obtained by using the linear programming method for Markovian Sequential Precision developed by Alan Mann. (H. Hinomoto)

8.2 Instructional Problem Specifications

During the third quarter of 1966, 3 instructional problem specifications were submitted to the Department for computation. The following brief descriptions of these problems have been prepared for inclusion in this report by those submitting them.

I424-69015 Industrial Engineering 282. Production Process Planning. Production Process Planning involves calculations for cutting and operation times and for annual cost; made for a number of different machines capable of doing a job to ascertain which is most economical. (L. E. Doyle)

I446-69044 Aeronautical and Astronautical Engineering 264. Analysis of Experimental Data. Experimental data for flight vehicle structural phenomena will be analyzed by using computer methods. (H. H. Hilton)

I459-69064 Educational Psychology 494. Class Exercises in Multivariable Analysis. Problems will concern multivariate statistical analysis, involving matrix inversion, eigenvalue and eigenvector problems, etc. (Tatsuoka)

8.3 Blanket Class Problem Specifications

During the third quarter of 1966, 71 problem specifications were submitted to cover all assigned problems in the following courses:

J399-67014	Nuclear Engineering 495.
J400-67015	Civil Engineering 391.
J401-67016	Electrical Engineering 389.
J402-67017	Psychology 390.
J403-67018	Civil Engineering 368.
J404-67019	Theoretical and Applied Mechanics 311.
J405-67054	Mechanical Engineering 260.
J406-67063	Mechanical Engineering 271.
J407-67068	Anthropology 353.
J408-67099	Economics 374.
J409-67105	Graduate School of Business Administration 531.
J410-68008	Mathematics 996.
J411-68009	Mathematics 195.
J412-68010	Mathematics 149.
J413-68017	Mechanical Engineering 264.

J414-68018	Mechanical Engineering 263.
J415-68019	Mechanical Engineering 215.
J416-68020	Mechanical Engineering 214.
J417-68025	Department of Computer Science 387.
J418-68026	Mechanical Engineering 260.
J419-68027	Mechanical Engineering 421.
J420-69002	Chemistry and Chemical Engineering 397.
J421-69007	Mechanical Engineering 271.
J422-69008	Psychology 306.
J423-69009	Aeronautical and Astronautical Engineering 232.
J425-69020	Electrical Engineering 323.
J426-69021	Nuclear Engineering 456.
J427-69022	Aeronautical and Astronautical Engineering 216.
J428-69023	Civil Engineering 262.
J429-69024	Civil Engineering 391.
J430-69025	Civil Engineering 391.
J431-69026	Mathematics 387.
J432-69029	Mechanical Engineering 341.

J433-69030	Industrial Engineering 386.
J434-69032	Agricultural Engineering 331.
J435-69033	Agricultural Engineering 221.
J436-69034	Marketing 422.
J437-69035	Chemistry and Chemical Engineering 394.
J438-69036	Civil Engineering 368.
J439-69037	Civil Engineering 361.
J440-69038	Theoretical and Applied Mechanics 428.
J441-69039	Engineering Honors 297.
J442-69040	Theoretical and Applied Mechanics 425.
J443-69041	Theoretical and Applied Mechanics 235.
J444-69042	Sociology 386.
J445-69043	Aeronautical and Astronautical Engineering 426.
J447-69045	Agronomy 365.
J448-69046	Mechanical Engineering 221.
J449-69047	Department of Computer Science 295.
J450-69048	Agricultural Economics 325.
J451-69049	Agricultural Economics 341.

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J453-69051	Theoretical and Applied Mechanics 311.
J454-69052	Aeronautical and Astronautical Engineering 261.
J455-69053	Electrical Engineering 389.
J456-69054	Mechanical Engineering 302.
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J461-69066	Graduate School of Business Administration 532.
J462-69067	Aeronautical and Astronautical Engineering 451.
J463-69068	Nuclear Engineering 401.
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J465-69073	General Engineering 221.
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J467-69075	Psychology 332.
J468-69084	Theoretical and Applied Mechanics 224.
J469-69085	General Engineering 288.
J470-69086	Electrical Engineering 322.

J471-69087 Mechanical Engineering 257.

J472-69088 Mechanical Engineering 256.

9. SWITCHING THEORY AND LOGICAL DESIGN

Enumeration of all threshold functions of eight variables and statistics of optimum weights of threshold elements are interesting problems, because they show insight into some theoretical conjectures. S. Muroga, T. Tsuoboi, and C. Baugh are working on these problems using ILLIAC II. Threshold functions of seven variables were studied by R. Winder of RCA, using an RCA computer. The threshold functions of eight variables would be a practical limit of computation with currently available computers.

The computation was finished during this period. 319,124 canonical two-monotonic positive self-dual functions are generated. Then the same number of linear programming problems were solved by ILLIAC II, taking about ten hours. 175,428 of these functions proved to be threshold functions. During computation, statistics on optimum weights, i.e. optimum solutions of the linear programs, were accumulated and algebraic properties such as complete monotonicity were checked. A question, whether there are completely monotonic functions of eight variables which are not threshold functions, which had been much argued among some switching theorists was closed. There is none. We found that threshold functions of eight variables contain some functions whose optimum weights are types which did not occur for seven or fewer variables. In other words some threshold functions have multiple optimum weights and some others have non-integral optimum weights.

Y. Yen, when he was working on his Ph.D. thesis, worked on the theory of a threshold element with multiple-thresholds and obtained interesting results, such as the bounds on weights and synthesis algorithms.

During this period, a preliminary study of the logical design of a network by integer linear programming was made. A new logical design procedure using integer linear programming was proposed by S. Muroga in 1965. Optimum networks with practically any sort of electronic gates such as threshold gates, NAND or NOR gates can be designed by this approach, under maximum fan-ins and fan-outs restrictions.

S. Muroga

10. GENERAL LABORATORY INFORMATION

10.1 Personnel

The number of people associated with the Laboratory in various capacities is given in the following table:

	Full-Time	Part-Time	Full-time Equivalent
Faculty	15	2	16.0
Visiting Faculty	3	0	3.0
Research Associates	1	0	1.0
Graduate Research Assistants	4	77	42.0
Graduate Teaching Assistants	0	1	0.5
Professional Personnel	13	1	13.5
Administrative and Clerical	17	1	17.5
Nonacademic, Monthly	69	2	69.75
Nonacademic, Hourly	0	75	31.6
	122	159	194.85

The Computer Advisory Committee consists of Professor J. R. Pasta, Head of Department; Professor J. N. Snyder, Associate Head of the Department; Professors L. D. Fosdick, H. G. Friedman, C. W. Gear, D. B. Gillies, D. J. Kuck, B. H. McCormick, S. Muroga, T. A. Murrell, J. Nievergelt, W. J. Poppelbaum, S. R. Ray, J. E. Robertson, and D. L. Slotnick.

10.2 Bibliography

During the quarter, the following publications were issued by the Laboratory.

File Numbers

(1) Amendola, Robert C., "External Service Lines of the ILLIAC III Communications Net," File No. 706, August 30, 1966.

(2) Amendola, R. C., "Circuit Board/Component Illustrations for ILLIAC III," File No. 709, September 12, 1966.

(3) Atkins, Daniel E., "Arithmetic Unit of ILLIAC III: Simulation and Logical Design - Part I," File No. 713, September 27, 1966.

(4) Kato, Masao, "Arithmetic Array: A Computer Organization with Integrated Circuits," File No. 698, June 1, 1966.

(5) Kato, Masao, "Hardware Design Problems for Preliminary Specifications of ILLIAC IV
I. Simultaneous Submultiple Precision Operations," File No. 714, September 9, 1966.

(6) Marks, Richard E., "A Survey of Memory Devices for Use as a Bulk Storage Device for ILLIAC IV," File No. 708, September 9, 1966.

(7) McCormick, Bruce H., "Current Goals of the ILLIAC III Computer Project: I. The Central Computer System," File No. 711, September 27, 1966.

(8) McCormick, Bruce H., "Current Goals of the ILLIAC III Computer Project: II. The System of Remote Video Consoles with Centralized Visual Data Processing," File No. 712, September 27, 1966.

(9) Miller, R. L., "The Analog-Digital and Digital Analog Conversion Facility of ILLIAC II," File No. 710, August 15, 1966.

(10) Muroga, S., "Logical Design of an Optimum Network by Integer Linear Programming," File No. 700, July 11, 1966.

(11) Nuspl, S. J. and Willard, R. E., "Engineering Commentary on the SPU Channel Logic," File No. 704, August 19, 1966.

(12) Pisterzi, M. J. and Miller, R. L., "The Teletype Subsidiary Special Register of the Multiplexing Special Register System," File No. 707, September 9, 1966.

(13) Squires, Burton E., "Precedence Grammars and the EULER System Part III: A Version of EULER for Hardware Implementation," File No. 699, July 12, 1966.

(14) Squires, Burton E., "Precedence Grammars and the EULER System Part IV: A Precedence Grammar for a Lexical Analysis," File No. 701, July 19, 1966.

(15) Squires, Burton E., "Precedence Grammars and the EULER System Part V: Logic for Connecting the Lexical Analysis with the Programming Language," File No. 703, August 15, 1966.

(16) Willard, R. E., "Programming Aspects of the SPU Channel," File No. 702, August 1, 1966.

(17) Willard, R. E., "Modifications to the DEC 630 Communications Control Unit," File No. 705, August 19, 1966.

Report Numbers

(1) Fisher, R. O. and Shepard, C. D., "Time-Sharing on a Computer with a Small Memory," Report No. 207, July 20, 1966.

(2) Fosdick, Lloyd D., Chairman; Gear, C. W., Kuck, D., Muroga, S., and Ray, S. R., "The Graduate Program in Computer Science," Report No. 212, August 25, 1966.

(3) Holland, Lester M., Jr., "An Elementary Discussion of the Time Share Concept," Report No. 206, July 5, 1966.

(4) Law, Kenneth C., "A Report on the Microfiche Industry and Comparative Analysis," Report No. 216, September 26, 1966.

(5) Ray, Sylvian R., "On the Application and Design of an Image Store," Report No. 210, August 22, 1966.

(6) Robertson, James E. and DCS Staff, "Final Report AEC Contract AT(11-1)-415," Report No. 205, July 1, 1966.

(7) Squires, Burton E., "Compiler Systems and Metalanguages," Report No. 208, August 1, 1966.

Theses

(1) Faiman, Michael, "Theory of Electron Transport Processes in Tunnel Diodes," (Ph.D.), Report No. 214, September 19, 1966.

(2) Hassler, Edwin Bernard, Jr., "Editing Compilers, Their Feasibility and Effects," (Ph.D.), Report No. 209, September 1, 1966.

(3) Yeh, Raymond, Tzuu-Yau, "Weak Congruence Relations on Graphs," (Ph.D.), Report No. 213, September 1, 1966.

(4) Yen, Yao-Tung, "Multi-Threshold Threshold Logic," (Ph.D.), Report No. 211, August 26, 1966.

Specification Numbers

(1) Afuso, Chushin, "Specifications for Electronic Counter," File No. 550-83, July 13, 1966.

(2) Amendola, Robert C., "Specifications for Microfiche Equipment
Section 1: A Microfiche Camera
Section 2: Microfiche Duplicating Equipment
Section 3: Microfiche Readers," File No. 550-84, August 24, 1966.

(3) Casasent, D. P., "Specifications for Four Inch High Vacuum System," File No. 550-85, September 6, 1966.

(4) Kubitz, W. J., "Specifications for Pulse Generator," File No. 550-80, July 8, 1966.

10.3 Colloquia

"An Evolution of Structures," by Mr. Ronald Resch, Instructor, Art Department, University of Illinois, Urbana, Illinois, September 19, 1966.

"The Monte Carlo Method," by Mr. R. R. Coveyou, Oak Ridge National Laboratory, Oak Ridge, Tennessee, September 26, 1966.

"Fourier Analysis of Random Number Generators," by Mr. R. R. Coveyou, Oak Ridge National Laboratory, Oak Ridge, Tennessee, September 27, 1966.

10.4 Drafting

During the quarter, a total of 1,010 drawings were processed by both drafting sections:

	General and ILLIAC II	Pattern Recognition
Large Drawings	112	8
Medium Drawings	397	74
Small Drawings	116	9
Layouts	0	48
Report Drawings	0	13
Changes	9	181
Miscellaneous	2	38
Semiconductor Coding	0	3
TOTAL	636	374

(K. Law, L. Prendergast)

10.5 Shops' Production

Job orders processed and completed during the third quarter of 1966, are as follows:

Facility	AEC 1018	AEC 1469	Other
Machine Shop	51	33	1
Electronics Shop	47	18	
Etch Shop	30	11	
Layout Shop	26	20	

Wiring of 571 standard circuit boards during this period, accounted for 34,965 diodes and 8,383 transistors.

Frank P. Serio

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Physics

COO-1469-0064

QUARTERLY TECHNICAL PROGRESS REPORT

October, November, December 1966

DEPARTMENT OF COMPUTER SCIENCE · UNIVERSITY OF ILLINOIS · URBANA, ILLINOIS

QUARTERLY TECHNICAL PROGRESS REPORT

October, November, December 1966

Department of Computer Science
University of Illinois
Urbana, Illinois 61801

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1. CIRCUIT RESEARCH PROGRAM

(Supported in part by the Office of Naval Research Under Contract Nonr-1834(15).)

Summary

The existing Paramatrix device is being modified to incorporate a slide scanner instead of a bank of potentiometers. Details are supplied by Larry Ryan.

Dick Koo has started the new project of the Photoconductive Matrix. This is a method of switching an array of signals, employs a scanning light beam and makes use of the properties of high dark-to-light resistance ratio and asymmetric response times of photoconducting elements.

In the area of Random Sequence Coding an analog-to-RPS converter has been designed and the problem of restandardization has been circumvented with the adoption of a synchronizing technique---described by Chushin Afuso. He has now been joined by John Esch who is investigating a representation for negative numbers.

Tak Katoh gives details of the Electroluminescent Panel driver system.

Finally, the state of Geomatrix is reported on by Bill Steiner.

1.1 Paramatrix (Project No. 01)

1.1.1 Introduction

A revised design of a slide-scanning system for Paramatrix is discussed. The principal components of the scanning system are a cathode ray tube (CRT), a linear amplifier, an accurate, high-speed analog comparator with variable sensitivity, two linear sweep circuits, and a high speed photo-cell with associated wave-shaping circuitry. These are intended to process line drawings in the form of photographic negatives---transparent detail on opaque ground.

1.1.2 Slide Scanner

As shown in Figure 1, the horizontal deflection of the CRT beam is controlled by X_{ij}, which is generated by the Paramatrix Transformer and represents the horizontal co-ordinate of a test point on the slide. The vertical deflection is determined by a linear sweep circuit.

The start of each Paramatrix clock cycle triggers the vertical sweep so that the CRT beam scans the column of the slide corresponding to X_{ij}. The photo-cell and associated wave-shaping circuitry behind the slide produce a short pulse (about 100 ns in width) every time a line on the slide (transparent lines on a dark slide) is traversed by the CRT beam. Another sweep, called the compare sweep, ranging linearly from -8 volts to +8 volts, is triggered in synchronism with the vertical sweep and forms one input to an analog comparator. The other input to the comparator is Y_{ij}, which corresponds to the vertical displacement of a test point on the slide. When the compare sweep comes within ϵ volts (as determined by the comparator sensitivity) of Y_{ij}, the comparator output becomes a logical "1" and remains in that state until the compare sweep exceeds Y_{ij} by ϵ volts. It is now clear that if the photo-cell unit produces a pulse while the comparator output is at state "1", then the bulb (X_i, Y_j) is to be lit. To accomplish this, the outputs of the photo-cell unit and the comparator are gated to set a flip-flop. The output of the flip-flop is then sent to the Comparison Unit of Paramatrix.

1.1.3 Gap Filling

An elementary form of filling in gaps will be done by expanding the CRT beam in the horizontal direction centered about X_{ij}. In this way adjacent columns of X_{ij} will be scanned during each clock cycle. A gap will be filled if an adjacent column of X_{ij} contains a line segment within ϵ of Y_{ij}.

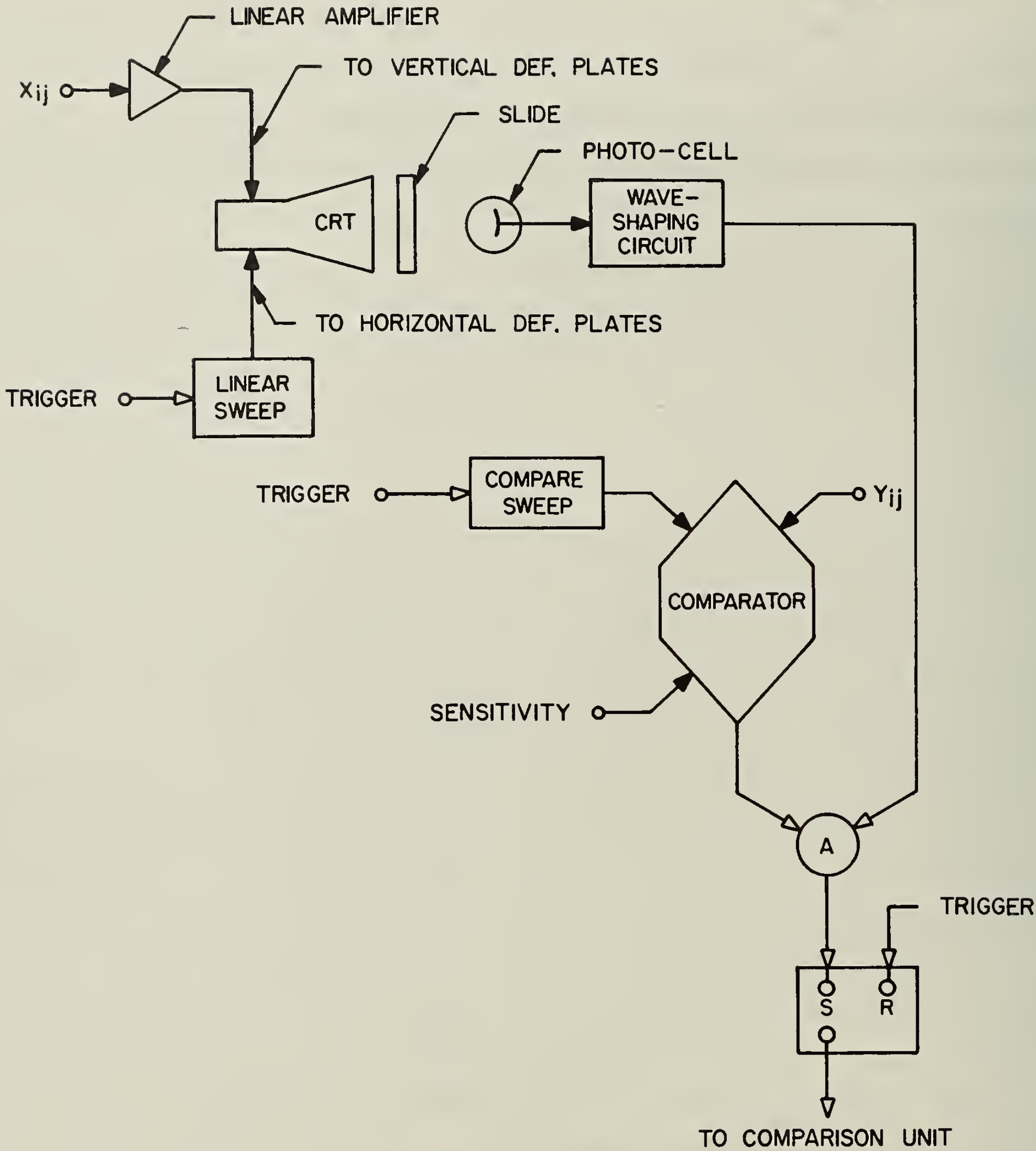


Figure 1. Slide Scanning System for Paramatrix.

1.2 Photoconductive Matrix (Project No. 02)

1.2.1 Introduction

An important property of photoconductors is that they can be made with highly asymmetric response times, as shown in Figure 1. The ratio of fall to rise time, on application of a symmetric light pulse, can be about one hundred or even larger. If such a photoconductor is illuminated by a train of light pulses of suitably chosen amplitude, frequency and width, its resistance can be maintained at a level low enough to constitute a closed switch.

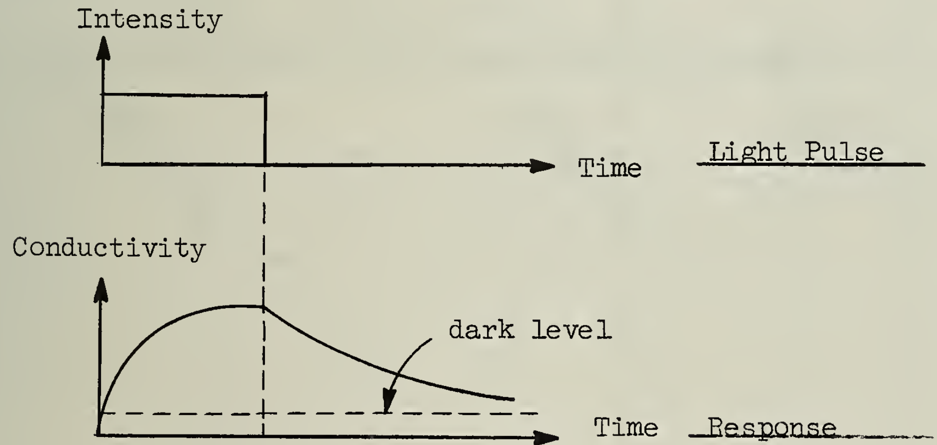


Figure 1. Response of Photoconductor to Light Pulse.

The photoconductive matrix is a rectangular array of asymmetrically responding photoconductors, as shown in Figure 2. Any one of X_1, X_2, ..., X_m (inputs) can be "connected" to any one of Y_1, Y_2, ..., Y_n (outputs) by illuminating the appropriate photoconductor. Excitation is provided by an X-Y scanning light beam. The normal scan that gives no connections is between the rows of photoconductors; while a connection is established by superimposing a small deflection when the light beam is near the appropriate photoconductor. These situations are illustrated in Figure 3, which shows the scan path for a connection between X_3 and Y_2. The scan pattern runs continuously over successive frames, so that the selected photoconductor sees a train of light pulses (at the frame rate) and its average resistance is thereby reduced with respect to that of the unselected photoconductors.

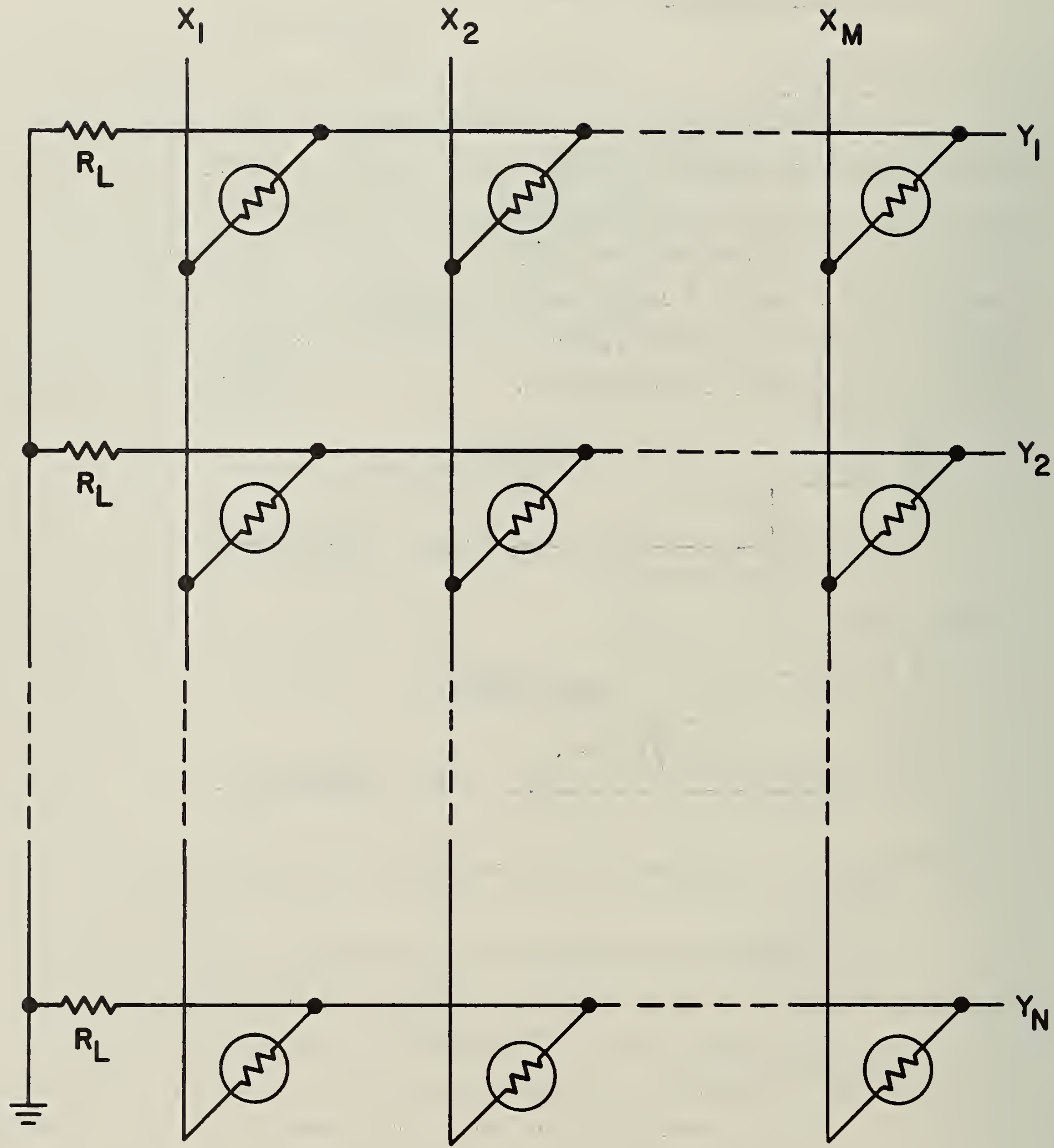


Figure 2. Photoconductive Matrix.

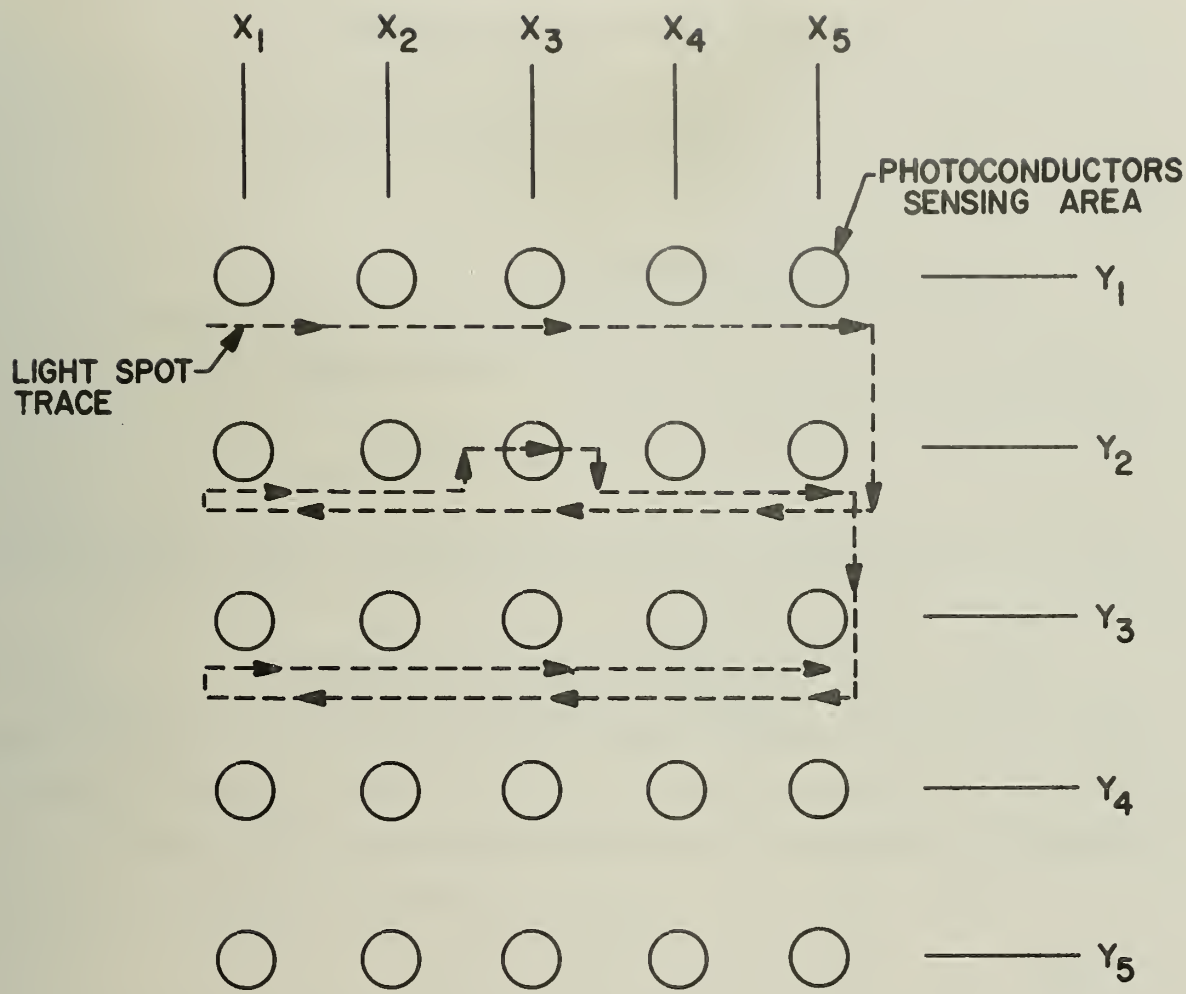


Figure 3. Light Scan for X_3-Y_2 Connection.

Heavy dotted line indicates forward scan; light dotted line indicates higher speed retrace.

It is seen that the photoconductor functions as an imperfect switch in this application, having a very high (dark) or very low (illuminated) resistance, rather than being open or short circuit. For a matrix of a given size, the dark resistance and load resistance will determine the efficiency of signal transmission and amount of cross-talk.

1.2.2 Solution of Kinetic Equation

For the sake of clarity we consider an n-type photoconductor. Its conductivity, σ, is related to the dark conductivity, σ_0, and the excess electron concentration, Δn, by:

$$\sigma = \sigma_0 + \mu e \, \Delta n \tag{1}$$

where e is the electronic charge and μ the mobility. An adequate approximation to the kinetic equation (assuming quadratic recombination) is:

$$d(\Delta n)/dt = \beta k I - \gamma (\Delta n)^2 \tag{2}$$

where β is the quantum yield, k the optical absorption coefficient, I the incident light intensity in photons per second and γ the recombination coefficient. Equation (2) can be simplified by the substitutions:

$$\Delta n = y; \quad \gamma t = x; \quad (\beta k I/\gamma)^{1/2} = a \quad (\geq 0) \tag{3}$$

yielding

$$dy/dx = a^2 - y^2 \tag{4}$$

The steady state solution to equation (4) for a periodic train of rectangular light pulses is shown in Figure 4.

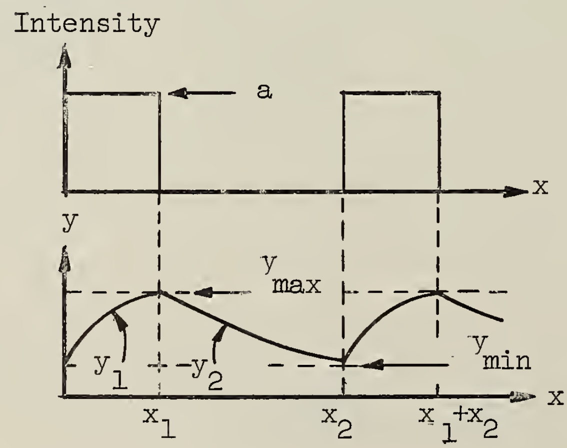


Figure 4. Photoconductor Response to Periodic Stimulus.

$$y_1 = a\tanh\,(ax + A),\ 0 \le x \le x_1$$
$$y_2 = 1/(x + B),\ x_1 \le x \le x_2 \tag{5}$$

where the integration constants, A and B, are determined by the conditions that $y_1(0) = y_2(x_2)$ and $y_1(x_1) = y_2(x_2)$, i.e.,

$$y_{min} = a\tanh A = 1/(x_2+B) \tag{6}$$

$$y_{max} = a\tanh\,(ax_1+A) = 1/(x_1+B) \tag{7}$$

Eliminating A and B from equations (6) and (7) gives:

$$y_{max/min} = \frac{a\left[\sqrt{4+4a(x_2-x_1)\coth ax_1 + a^2(x_2-x_1)^2} +/- a(x_2-x_1)\right]}{2 + 2a(x_2-x_1)\coth ax_1} \tag{8}$$

The final quantity of interest is the average value of the excess concentration, y_{av}, given by:

$$x_2 y_{av} = \int_0^{x_1} y_1 dx + \int_{x_1}^{x_2} y_2 dx \tag{9}$$

This is readily evaluated using equations (5) through (8). The result is:

$$y_{av} = \frac{1}{x_2} \log \left\{ \frac{y_{max}\sqrt{a^2-y^2_{min}}}{y_{min}\sqrt{a^2-y^2_{max}}} \right\} \tag{10}$$

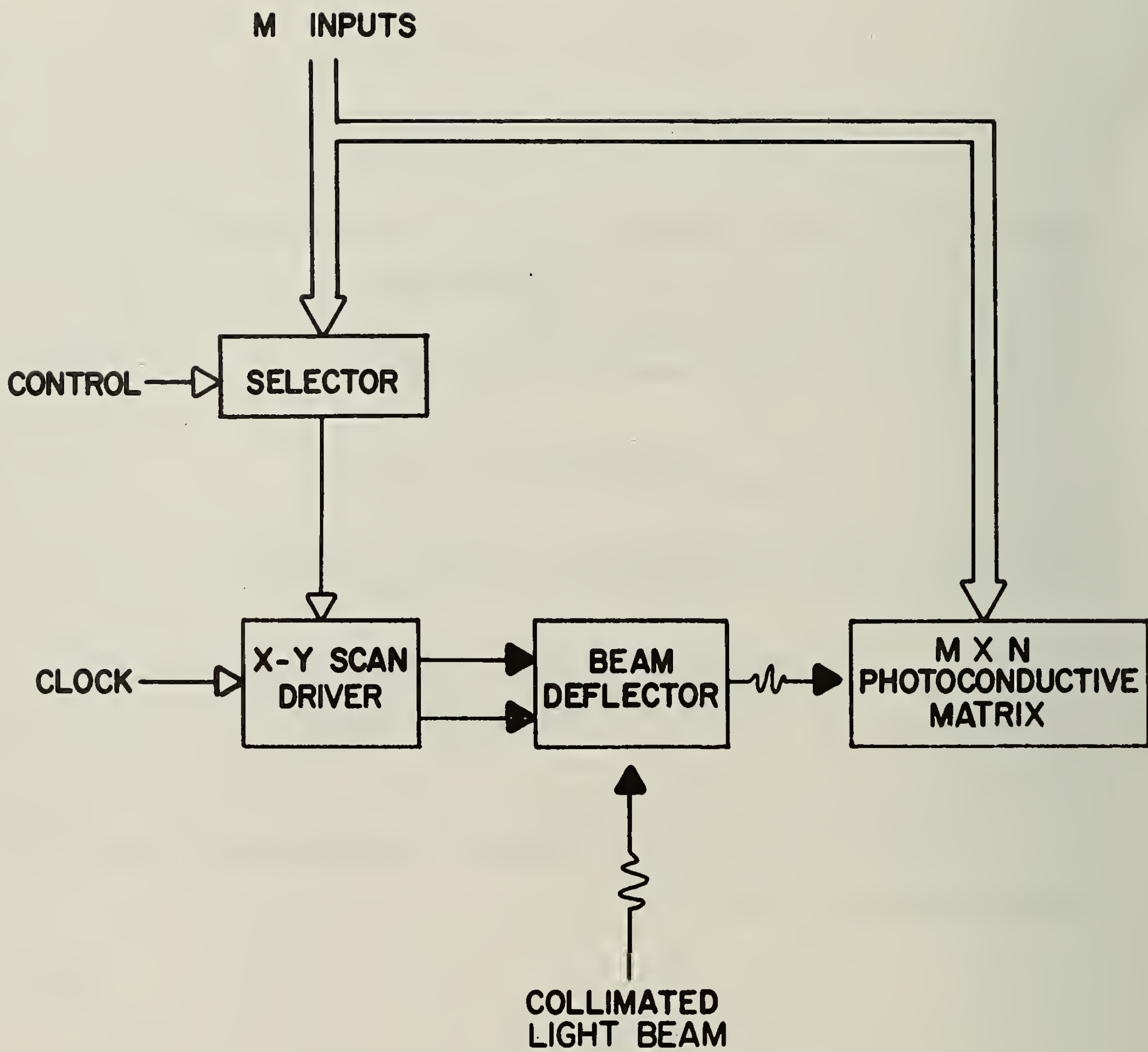


Figure 5. Block Diagram of Photoconductive Matrix.

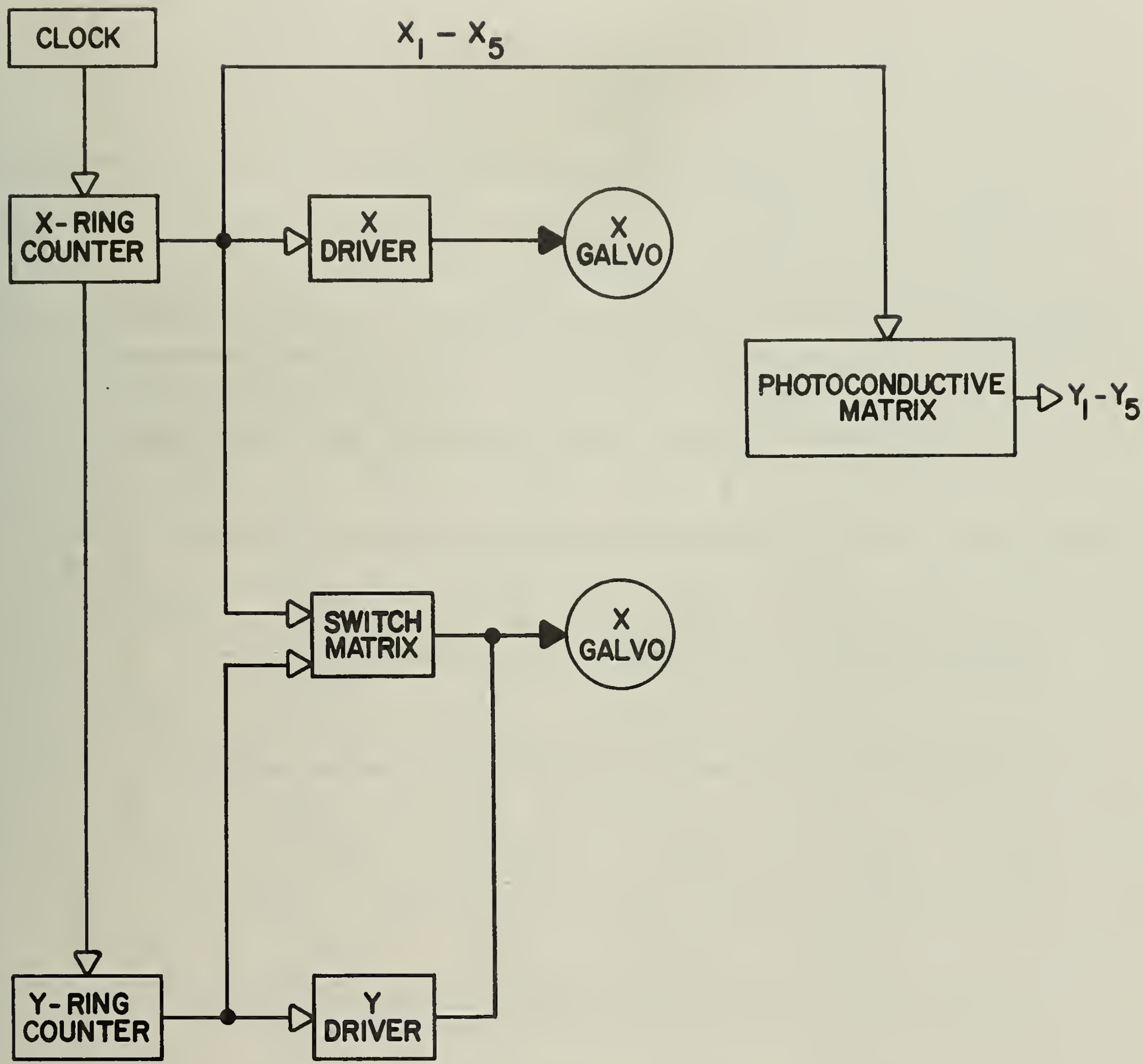


Figure 6. Block Diagram of Preliminary System.

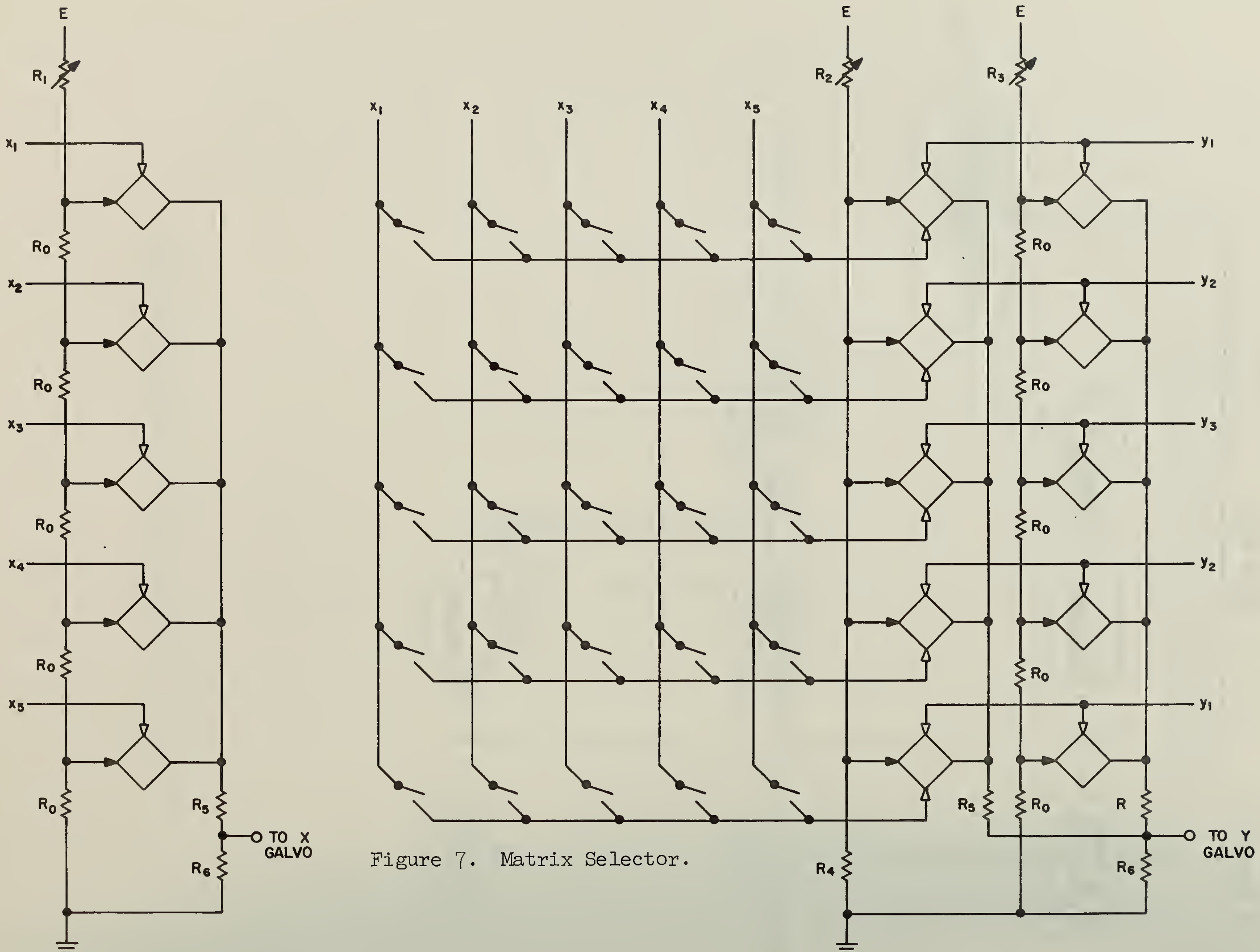


Figure 7. Matrix Selector.

1.2.3 System and Circuits

A block diagram of the photoconductive matrix is shown in Figure 5. The light beam deflector consists of two galvanometers of a special type having a frequency response from DC to 20 kHz. Its X-Y scan driver generates staircase waveforms---for a given scan frequency such waveforms allow the light beam to illuminate a given photoconductor for a longer time than would be possible with a conventional sawtooth waveform. The selector allows the system to operate in either of two modes. The first mode is similar to that of telephone exchange switching in which the inputs are preceded in time by codes designed to specify a connection pattern in the photoconductive matrix. In the other mode the connection pattern is established by one or more separate control signals.

In order to test the matrix proper and light deflection components, a preliminary single mode system is currently being assembled. This is outlined in Figure 6. The selector is here replaced by a matrix of toggle switches, one for each photoconductor, with $m=n=5$. Two counters driven by a clock are fed to X and Y drivers to generate staircase deflection waveforms. Conveniently, the outputs of the X counter are also used as inputs to the photoconductive matrix. Figure 7 shows the layout of the preliminary matrix selector, corresponding to the X driver, switch matrix and Y driver of Figure 6. The signals x_1 through x_5 are the outputs of the X ring counter, each signal being displaced from its immediate neighbors by one pulse time. These signals are also used as the inputs, X_1 through X_5, to the photoconductive matrix. Signals y_1 through y_5 are similarly generated and are a factor five in time longer than the x signals. The X galvanometer driver employs five diamond gates, as shown on the left of Figure 7. The Y driver is similar, but incorporates in addition a series of doubly gated diamond circuits operated by the switch matrix shown. These have the effect of adding a small voltage increment to the Y drive, via summing resistor R_5, of magnitude determined by R_2 and R_4.

Dick Koo.

1.3 Random Sequence Coding

1.3.1 Introduction

The methods for analog-to-random pulse sequence conversion are discussed. The synchronous random pulse sequence system is proposed. There are advantages in this system over the old random pulse sequence system. A method of generating such a random pulse sequence is presented.

1.3.2 Analog-to-Random Pulse Sequence Converter

If random pulse sequences are to be acceptable for an analog computing system, it must be possible to generate them conveniently from analog quantities. Since it is the discrimination level that controls the average frequency of the random pulse sequence, the former must be controlled by analog quantities. Figure 1 shows a diode discriminator circuit. In this circuit I must be controlled such that the average frequency of the random pulse sequence is proportional to the analog input voltage. Two methods seem possible: One is direct and the other is a feedback method.

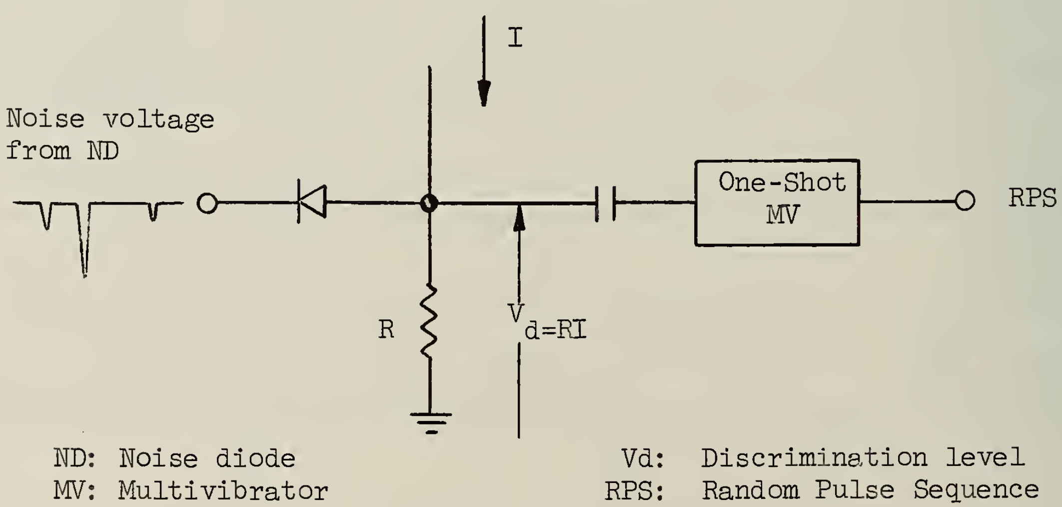


Figure 1. Diode Discriminator for the Random Pulse Sequence Generator.

1.3.3 Direct Method

The qualitative relation between the discrimination level, V_d, and the average frequency, ν, of the random pulse sequence is shown in Figure 2 (a). It is possible to synthesize a non-linear circuit having the V-I characteristic shown in Figure 2 (b), which is identical with V_d-ν in Figure 2 (a). By inserting such a circuit between the analog input terminal and the discriminator diode, as shown in Figure 3, the average frequency of the random pulse sequence may be controlled by the analog voltage linearly.

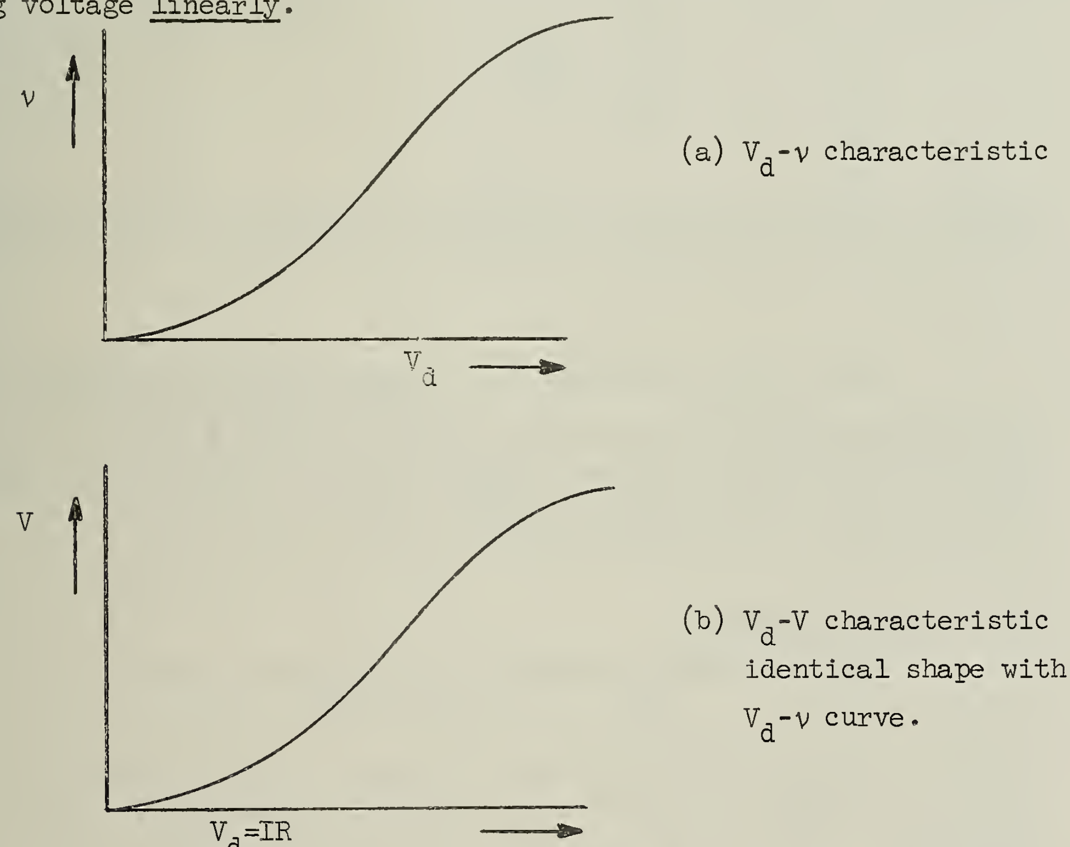


Figure 2. (a) Discrimination Level vs. Average Frequency for the Noise Diode; (b) Desired Characteristic for the Input Analog Voltage, V, vs. Discrimination Level.

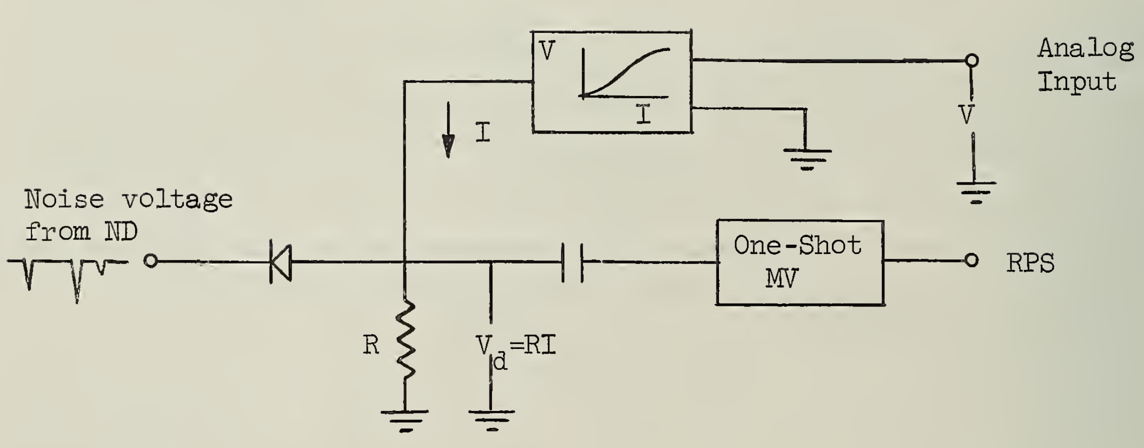


Figure 3. Analog-to-Random Pulse Sequence Converter by Direct Method.

The accuracy depends on how closely the V_d-ν and V-V_d characteristics agree with each other. The tolerance spreads of the noise diode characteristics and of the non-linear elements producing V-I characteristics seem to be the factors which determine the accuracy.

1.3.4 <u>Feedback Method</u>

In this method the output of a comparator, which compares the average voltage of a random pulse sequence and an analog input voltage, controls the discrimination level in such a way as to equalize the two compared voltages. A circuit for this method is shown in Figure 4. The comparator, in this case, consists of a single difference amplifier.

The sensitivity of the comparator is the only determining factor for the accuracy. The time constant of the averaging unit in front of the comparator sets the upper limit of speed.

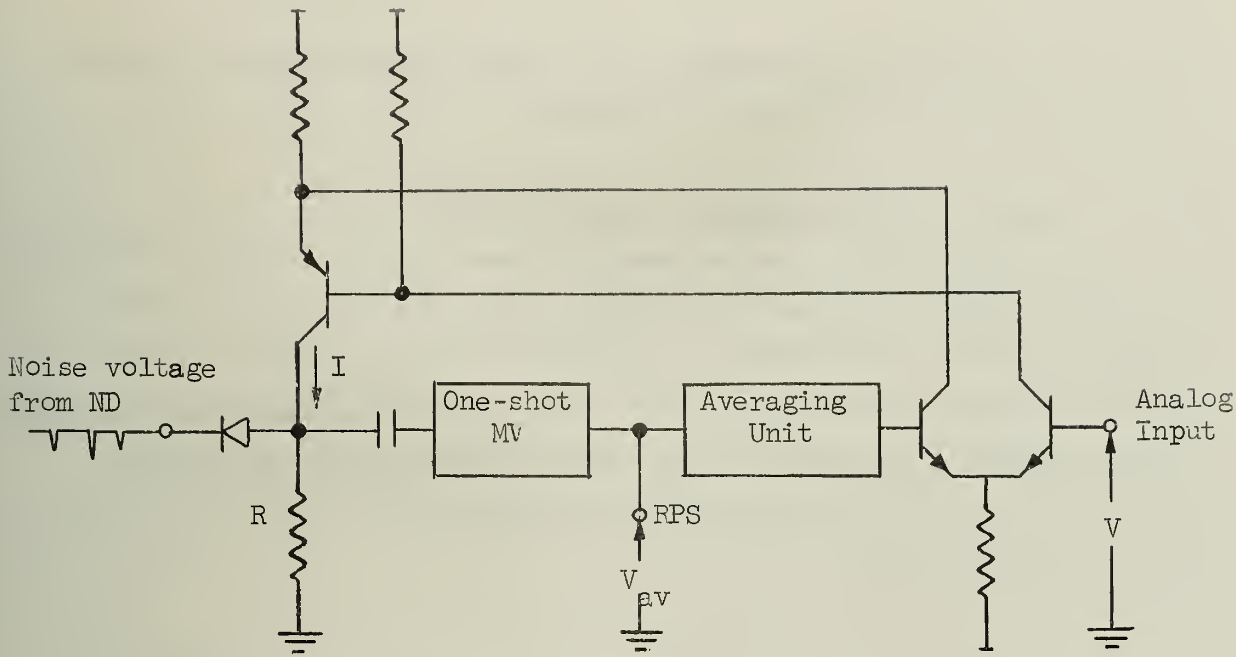


Figure 4. Analog-to-Random Pulse Sequence Converter by Feedback Method.

1.3.5 Comparison of the Methods

In order to compare the features of the two methods, let us consider the following numerical example. From the measured V_d-ν characteristics of three noise diodes (Clevite CND-012), at V_d=8.5V, the fractional spread was found to be

$$\Delta\nu/\nu = \Delta V_{av}/V_{av} \simeq 0.50/3.50 = 14\%$$

This rather poor accuracy comes from the noise diode itself. To this must be added the further error due to non-linear elements in the V-I transformer shown in Figure 3. On the other hand, a sensitivity of 50 mv may be easily obtained for the difference amplifier shown in Figure 4. Therefore

$$\Delta V_{av}/V_{av} = 0.05/3.50 \simeq 1.4\%$$

The average frequency corresponding to V_{av}=3.50V is ν = 350 kc (for V_0 = 10V, τ = 1 μs). For 1 ms time constant of the averaging unit, the fluctuation is about 5%. Thus 6.4% overall dynamic accuracy is obtained.

From the above example, it is clear that the feedback method is more attractive than the direct method.

1.3.6 Synchronous Random Pulse Sequence System

A synchronous random pulse sequence e(t) is defined as follows: it is a sequence of standardized pulses, each of which has the same height V_0, and the same width τ, such that the pulse repetition rate changes at random about the average value ν, and the instant of occurrence of each pulse is controlled by a central clock for the whole system. Only the last criterion differentiates this system from the old random pulse sequence system.

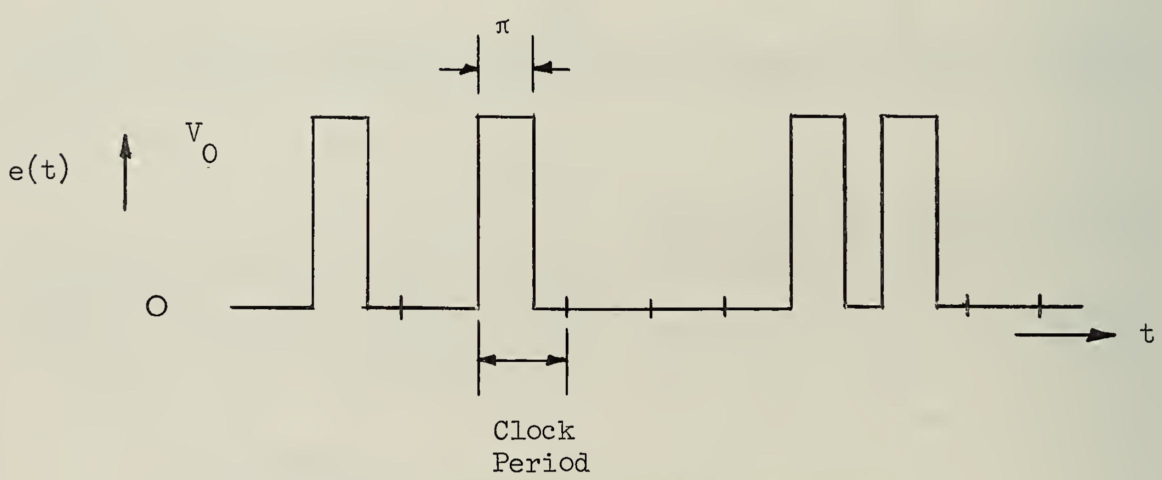
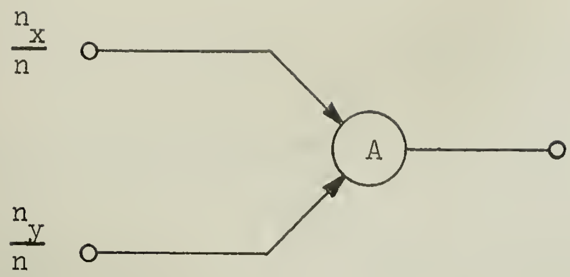


Figure 5. Synchronous Random Pulse Sequence

If n is the number of clock pulses during the averaging time, and n_x the number of pulses during n clock cycles, then the probability that a pulse appears at any clock cycle is given by n_x/n.

1.3.7 Multiplier

It is obvious that multiplication is performer with an AND gate in the same way as in the old random sequence system. The only difference in this case is that the output sequence is of the same type as the inputs because of the central clock. Therefore subsequent operations may be performed on the output sequence without having to regenerate a random sequence, as was necessary in the old random sequence system.



$$\frac{n_z}{n} = \frac{n_x}{n} \cdot \frac{n_y}{n}$$

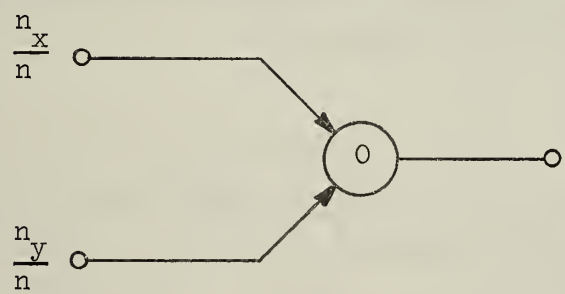
Figure 6. Multiplier

1.3.8 <u>Adder</u>

Use of an OR gate as an adder is possible. There are two advantages in this case:

a) The output sequence is of the same type as the inputs,

b) Compensation of the error due to coincidence of the two inputs is possible to any degree.



$$\frac{n_z}{n} = \frac{n_x}{n} + \frac{n_y}{n} - \frac{n_x}{n} \cdot \frac{n_y}{n}$$

Figure 7. Uncompensated Adder

The first order compensation is shown in Figure 8. When the two pulses appear at the same clock cycle at the input of an OR gate, there is only one pulse at the output because of coincidence, whereas we wish to have two as the algebraic sum. In order to compensate this, the output of an AND gate is fed to the OR gate after a oen clock cycle delay. Obviously this compensation is not complete if two input pulses coincide more than twice successively. This uncompensated amount is represented by

$-n_x^2 n_y^2/n^4$. Compensation of higher order is possible in the same manner.

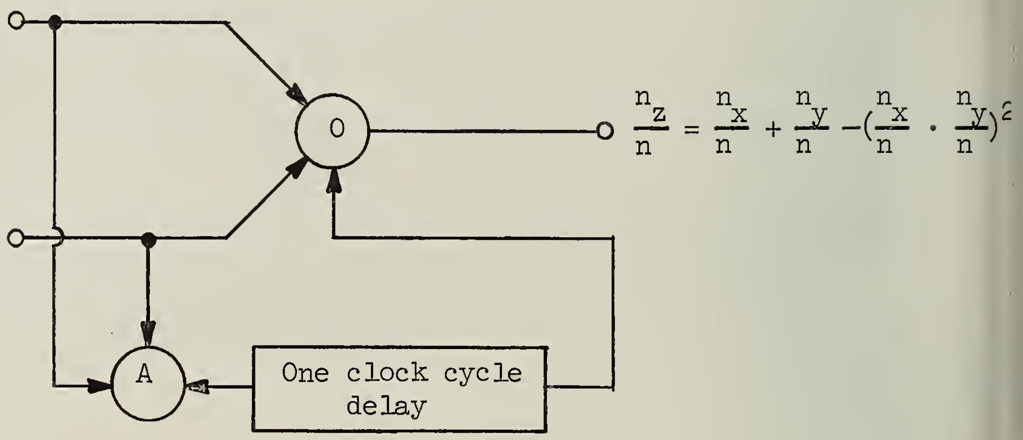


Figure 8. First Order Compensated Adder.

1.3.9 Generation of the Synchronous Random Pulse Sequence.

The block diagram of a synchronous random pulse sequence generator is shown in Figure 9. The set signals, the reset signals, and the outputs are shown in Figure 10.

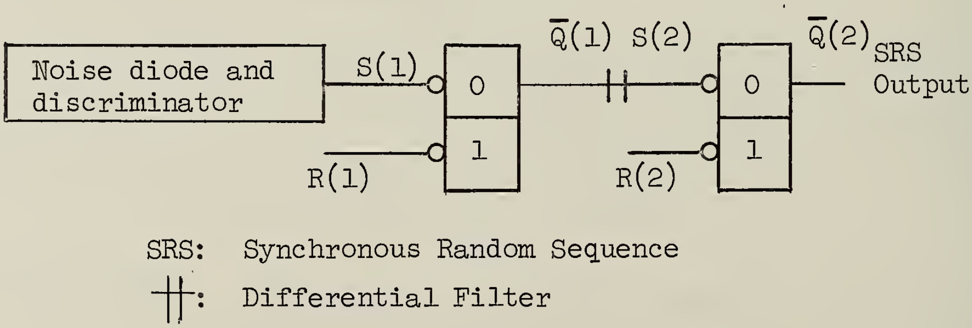


Figure 9. Block Diagram of a Synchronous Random Pulse Sequence Generator.

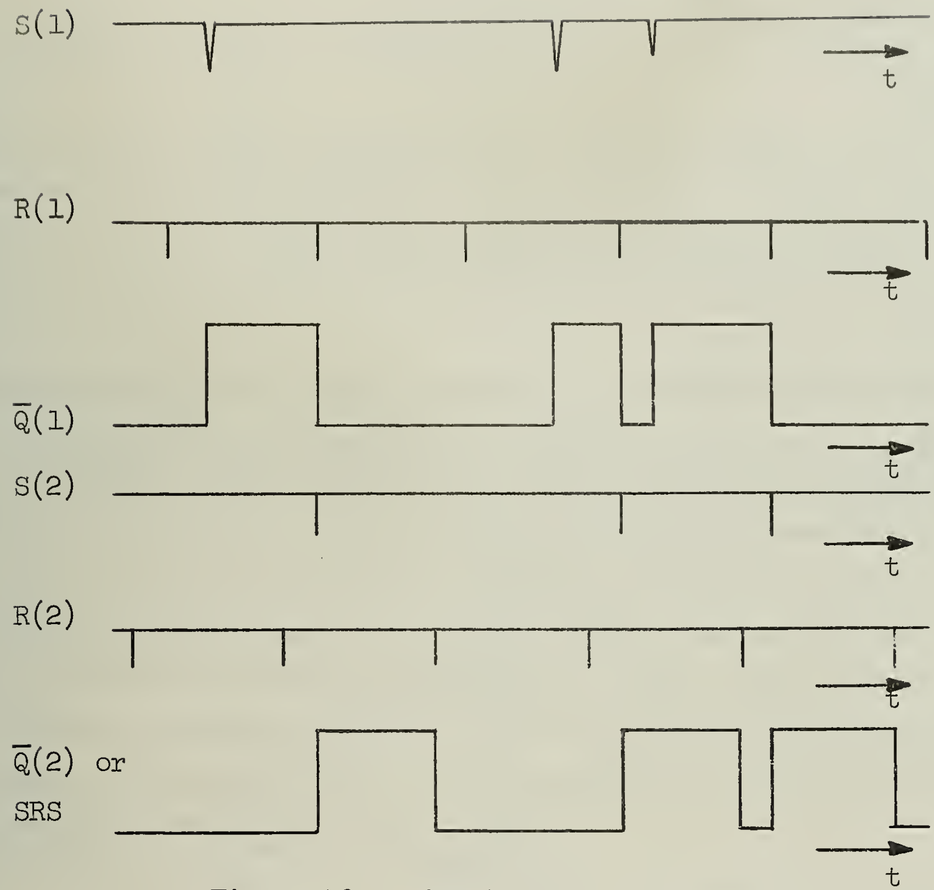


Figure 10. Signals of an SRS Generator.

1.3.10 <u>Problems for Future Investigation</u>

The subtracter and divider for the synchronous random sequence system will be developed. It is hoped that more digital operations may be done in such a system than in the old random sequence system, and consequently it may allow us to eliminate averaging at each operation.

1.3.11 <u>Negative Numbers</u>

If future uses and applications are to be made of the Random Sequence Coding methods developed to date, there is a need to supplement them with a means of representing negative numbers. Several different approaches are currently being investigated and it is hoped that one or more of these will soon be incorporated into a working system.

Chushin Afuso

John Esch

1.4 Electroluminescent Panel (Project No. 07)

1.4.1 Controls

A control system for the electroluminescent panel has been designed and is shown in Figure 1. Closing a switch corresponding to the intersection of the mth row and nth column of the panel causes light to be emitted from that intersection. There is no restriction on the number of intersections that may be lit at any time.

As has been explained in a previous report, the electroluminescent panel requires quite a high AC voltage for its operation. The optimum (square wave) frequency was experimentally found to be about 10kHz. A clock of this frequency is gated with the outputs of a five stage counter (Figure 1) and then decoded on 28 wires for the columns of the panel; these signals are also fed to the switch array. When a switch is closed, the corresponding intersection on the panel 'sees' the alternating waveform of Figure 2(c), this being the difference of (a) and (b). The high voltage is provided by special drivers (D and $\overline{D}$ in Figure 1), the circuit for which is shown in Figure 3.

Tak Katoh

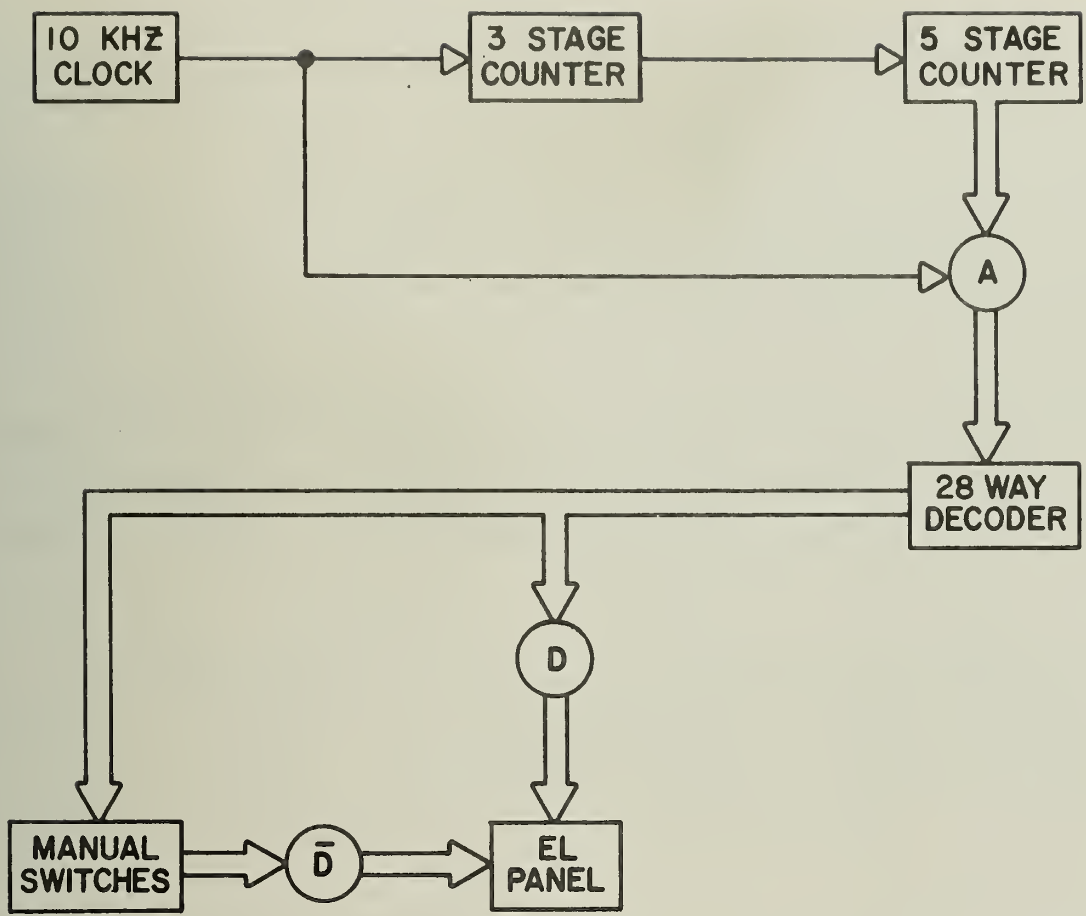


Figure 1. Electroluminescent Panel Control.

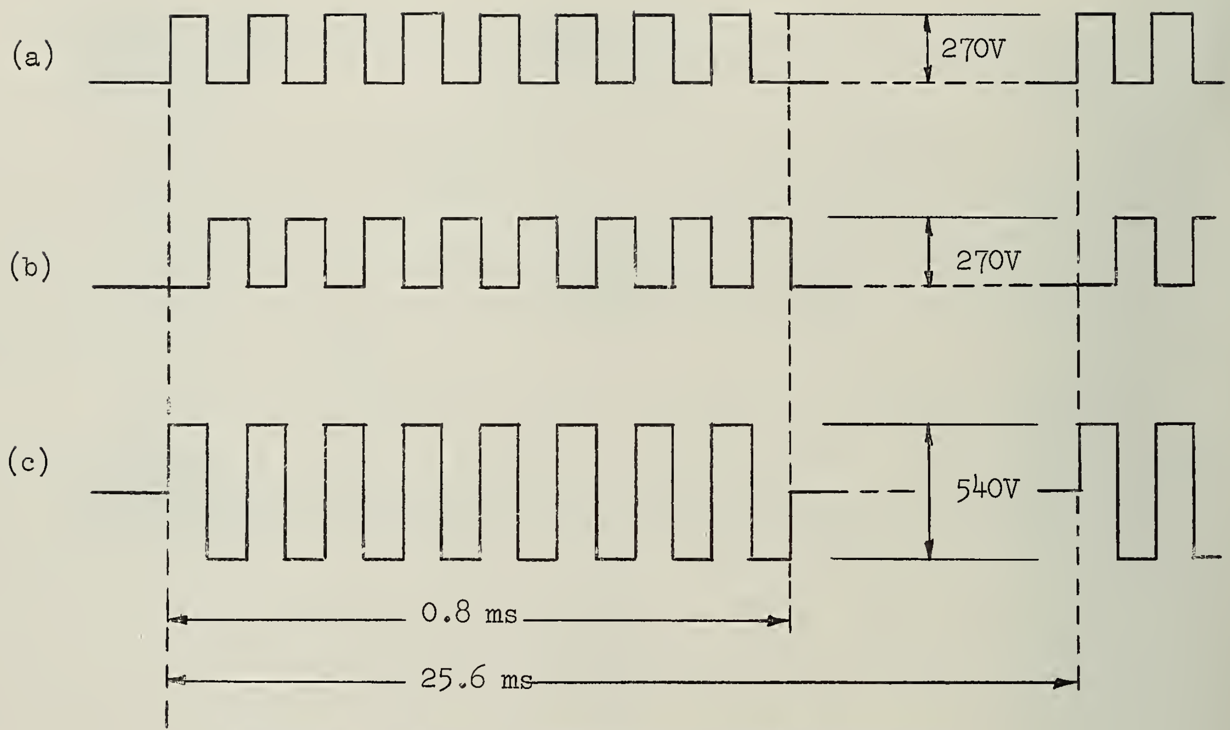


Figure 2. Electroluminescent Panel Waveforms.

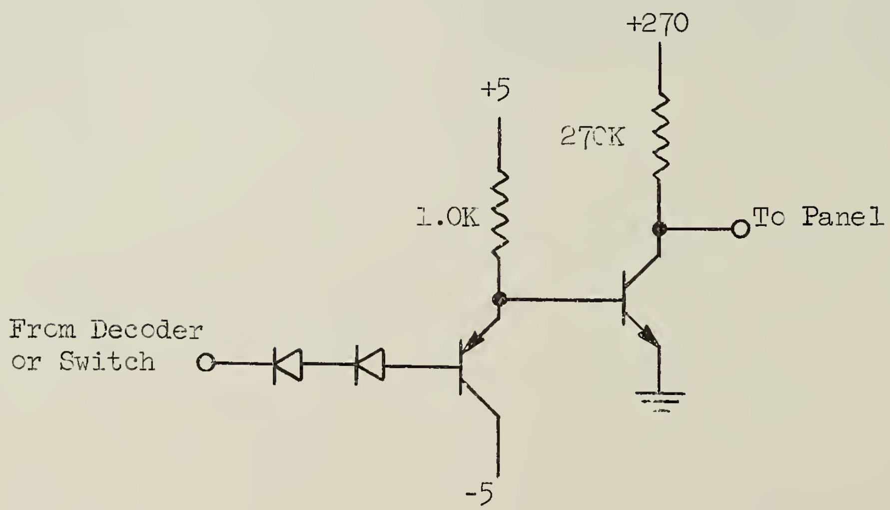


Figure 3. Panel Driver.

1.5 Geomatrix (Project No. 08)

1.5.1 Principle

The Geomatrix is an electronic system, utilizing hybrid digital-analog circuits, which generates straight line segments subject to given end points. Previous systems for performing this function have involved, generally speaking, generating electronically the equation of a straight line and testing raster points in order to see if they satisfy the equation of a straight line. The basic idea of the Geomatrix is to associate with each raster point an "autonomous element" that determines if the point lies on the desired line segment. The ultimate success of such a system depends on whether the "autonomous elements" can be made inexpensively.

1.5.2 Physical Configuration

The Geomatrix cabinet will contain all of the necessary equipment for its operation except power supplies. The control and output panel is shown in Figure 1. All components are mounted in one rack of printed circuit cards which are easily accessible from the top.

1.5.3 Electronic Configuration

The inexpensive "autonomous element" is a circuit which indicates if its two input voltages are equal by lighting a lamp. (This circuit is described in Q.T.P.R., January-March 1966, 1.01.03.3.) The scheme uses two resistor chains and several switching systems to control bus voltages for each point in the raster plane (Figure 2). An autonomous element sits at each raster point using the two bus voltages at that point as its inputs.

The requirement is that the bus voltages at each raster point be controlled in such a way that they are equal if that raster point is a point on the desired line segment and different otherwise.

This end is accomplished by two means. The bus voltages corresponding to the raster points which lie on the desired line segment are made equal by applying equal voltages to points on the resistor chains corresponding to end points on the line segment. Since all resistors in the chains are of the same value, the voltages divide up proportionally, making the bus voltages also equal for other raster points on the line segment.

Bus voltages for points lying outside the domain of the line segment must be made non-equal in order to properly terminate the line segment. This is accomplished by manipulating voltages at the ends of the resistor chains. The proper end voltages are selected and applied by logic wired into wafers on the selector switches and by a bank of three relays. There are three possible voltage combinations for terminating the resistor chains, and these combinations are called +, =, and -. The proper combination is determined by the end points of the line segment and is selected by the following criteria:

$$
\begin{array}{lllll}
+ & A_y > B_y & & A_x \neq B_x \\
= & A_y = B_y & \text{or} & A_x = B_x \\
- & A_y < B_y & & A_x \neq B_x .
\end{array}
$$

The voltages applied to the ends of the resistor chains under each combination are shown in Figure 2.

1.5.4 <u>State of Completion</u>

The Geomatrix is currently being assembled. The mechanical work is complete. The wiring is 50% complete. The printed circuits have been tested and are being assembled. Peripheral check-out equipment has been built and is available for use when needed.

Bill Steiner

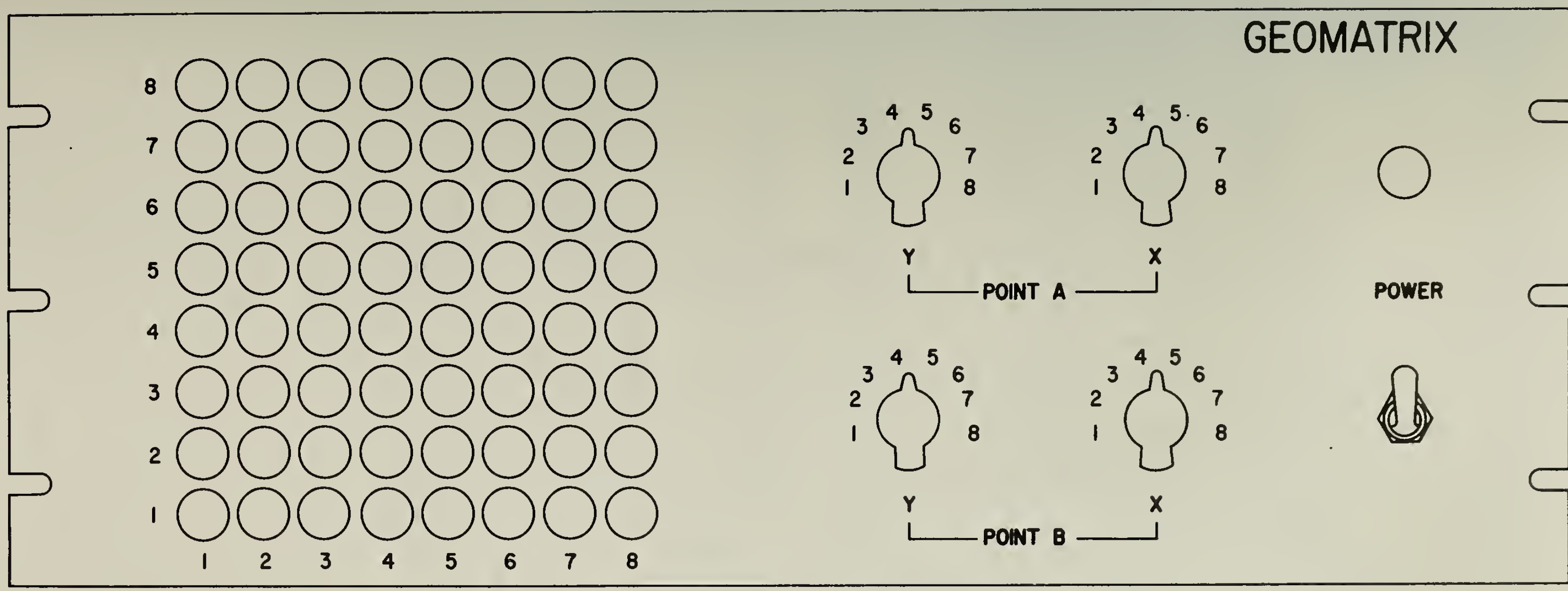


FIGURE 1. CONTROL AND OUTPUT PANEL OF GEOMATRIX

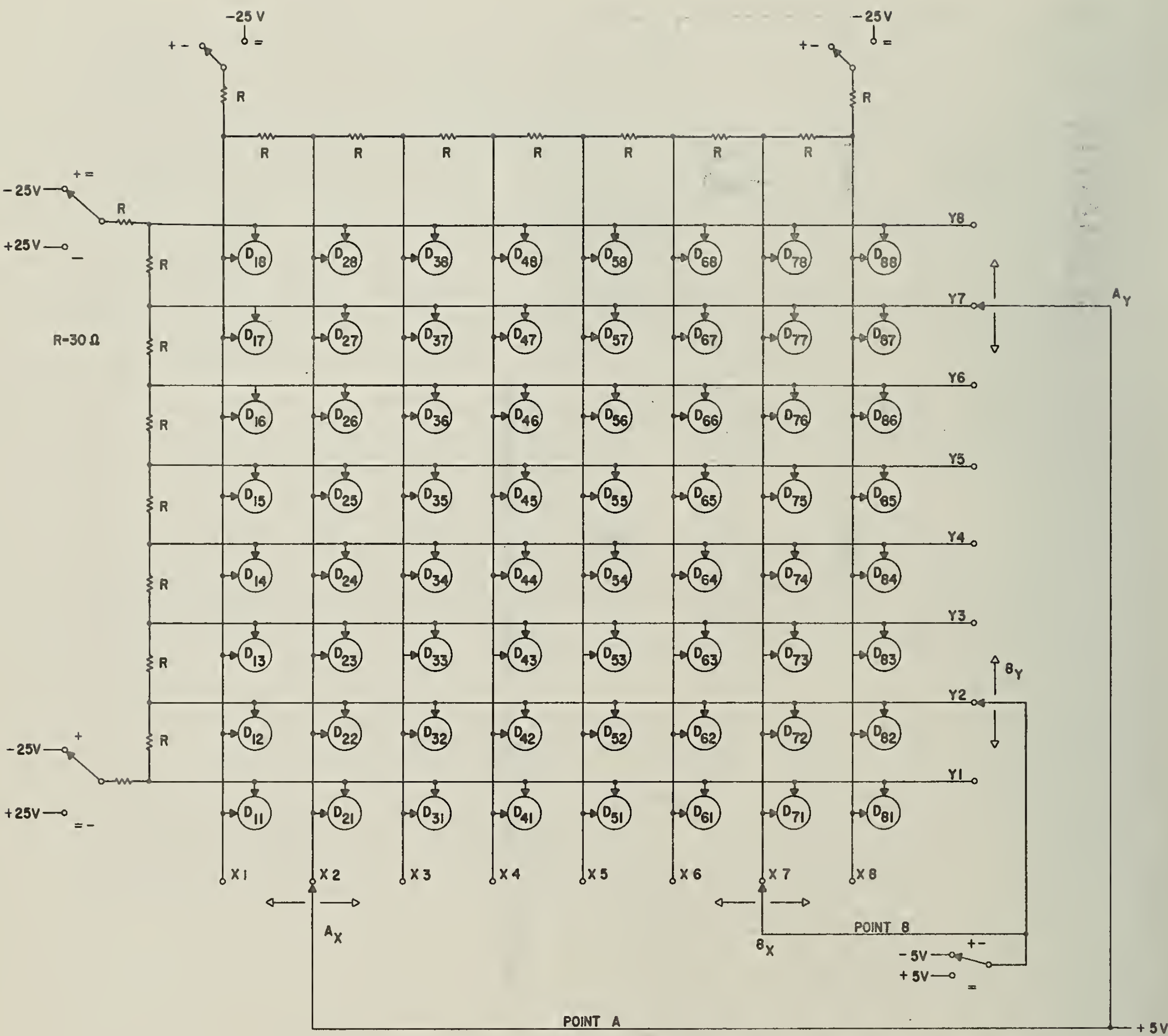


FIGURE 2 ELECTRONIC LAYOUT OF GEOMATRIX.

2. HARDWARE SYSTEMS RESEARCH

(Supported in part by the Atomic Energy Commission under Contract AT(11-1)-1469), W. J. Poppelbaum, Principal Investigator

Summary

Following developments in OLFT described by David Casasent and Douglas Sand, beginning reports on three new projects are given by David Rollenhagen, Peter Oberbeck, and William Kubitz. The first two deal with the bandwidth compression problem, one by means of an incremental differencing or "delta" method, the other by functional encoding. The third project is an outgrowth of Artrix; named the Automatic Tricolor Cartograph, its purpose is to extend Artrix techniques into the realm of automatic coloring of information displays.

2.1 On-Line Fourier Transform System (Project No. 12)

2.1.1 Linear Electro-Optic Effect

As described in previous reports, this project employs a light modulator in the form of a z-cut KDP crystal on which a charge pattern is written by an electron gun. A spot of charge creates a local electric field in the crystal, referenced to a conducting plane on its back surface, causing the crystal, which is uniaxial in its neutral state, to become biaxial. If now the charged part of the crystal is illuminated by polarized light of suitable orientation, the components along the two transverse crystal axes---the so-called ordinary and extraordinary rays---are subject to different refractive indices, and the relative phase change between these components effectively rotates the direction of polarization. Thus an electronic signal (electron beam modulation) is converted into an optical one (polarization modulation) and, further, this transduction can be carried out at video rates. The changes in the transverse refractive indices are proportional to the longitudinal component of the electric field. The total relative phase change between the two polarization

components in a single longitudinal passage through the crystal is therefore proportional to the length-integrated longitudinal electric field, i.e., to the local difference of potential across the crystal. Hence, this effect is dubbed 'linear' in contrast to the Kerr effect which is a quadratic function of (transverse) potential difference.

For light polarized at 45° to the transverse crystal axes and received though a crossed analyzer, the phase modulation is converted into an amplitude modulation and the resultant intensity is readily shown to be of the form:

$$I = I_0 \sin^2 \phi$$

where ϕ is the relative phase change of the two components. In the notation of reference (1) it is given by

$$\phi = \pi n_1^3 r_{63} V/\lambda = \pi V/2V_0$$

where n_1 is the field-free transverse refractive index, r_{63} is a crystal constant determining the magnitude of the electro-optic effect, V is the crystal voltage, λ the wavelength of the light and $V_0 = \lambda/2n_1^3 r_{63}$ is known as the half-wave retardation voltage---that which produces maximum modulation. Experimentally determined values of n_1 and r_{63} are given in reference (1):

$$\text{KDP:} \quad n_1 = 1.51, \qquad r_{63} = -1.05 \times 10^{-11} \text{ m/V;}$$

$$\text{KD}_2\text{P:} \quad n_1 = 1.51, \qquad r_{63} = 2.64 \times 10^{-11} \text{ m/V}$$

At a wavelength of 6328Å these figures give half-wave voltages (V_0) of about 8750 and 3480 for KDP and KD_2P, respectively.

---

(1) Kaminow and Turner, Appl. Opt. 5, 1612, 1966.

2.1.2 Write Gun Requirements

An estimate of the electron beam current that is required of the write gun can be made by regarding the crystal with its charge pattern as an array of capacitors, one for each of the maximum number of charge spots that can be written on the crystal surface. The derivation is elementary and yields the result:

$$I = \epsilon_0 \epsilon_3 \pi d^2 V_0 N / 4b(1-s)T \qquad \text{(M.K.S. units)}$$

where I is the beam current, ϵ_0 the permitivity of free space, ϵ_3 the relative dielectric constant normal to the crystal surface, d the charge spot diameter, N the number of spots per line sweep, b the thickness of the crystal, s the secondary emission ratio and T the sweep time. The magnitudes of the various quantities appearing in this expression are as follows:

$\epsilon_0 = (36\pi \times 10^9)^{-1}$ f/m; $\epsilon_3 = 21$ (KDP), 50(KD_2P); $d = 2.5 \times 10^{-5}$ m;
$N = 250$; $b = 2.5 \times 10^{-4}$ m; $T = 6 \times 10^{-5}$ s; s(timated) = 0.2;
$V_0 = 8750$(KDP), 3480(KD_2P) volts.

For either KDP or KD_2P the calculated beam current is about 16 microamps (the product $\epsilon_3 V_0$ is about the same for both materials). This result is at best a crude one, not only because of inherent uncertainties in the parameter values, but also because the model ignores both the interaction of the fields due to neighboring charge spots and the finite, if very high, resistivity of the crystal which causes the pattern to diffuse and decay in time. An analysis in closer accord with the true physical situation will be given in a subsequent report.

2.1.3 Vacuum System

The vacuum system will consist of three parts: a roughing pump, a sublimation pump, and an ion pump. Additional equipment will be a bakeout heater and Dewar flask for the roughing pump and appropriate valves and gauges. This system will be very clean and will provide an ion pumping speed of 20-200 liters per second depending

on the diameter of the port chosen, and a maximum overall pumping speed in excess of 4000 liters per second. These rates are felt to be more than adequate for our proposed system.

2.1.4 Chamber

The chamber that houses the KDP crystal is closed at each end by stress-free, optically flat glass windows of sufficient thickness and quality to maintain their flatness at 10^{-7} Torr pressures. This flatness is necessary so that no interference pattern is produced in the highly precise laser wavefront before the wavefront reaches the crystal. The chamber will be made of stainless steel with a rectangular cross section. The KDP target must be normal to the light path in order that the desired Fourier Transform can be constructed in the focal plane of the first lens. Obviously, there must be no obstruction between the front optical flat and the crystal target. Thus an off-axis electron gun must be employed. The writing gun is therefore inclined about 35° to the main optical axis. The erase gun is also mounted off-axis in a separate port, at such an angle as to achieve a complete electron spray over the target surface. Suitably placed beam-bending coils ensure that electrons from either gun strike the target perpendicularly.

The crystal will be mounted on an optically flat glass substrate spaced from the exit port in order to provide the same vacuum environment on each side of the crystal. The backing electrode on the crystal will be brought out externally and isolated from the chamber so that the various voltage combinations can be investigated. The stainless steel housing of the chamber necessitates that this be held at ground potential and the cathode of the electron gun at about 30 kV negative with respect to ground. Figure 1 shows a block diagram of the chamber and associated circuitry.

David Casasent
Douglas Sand

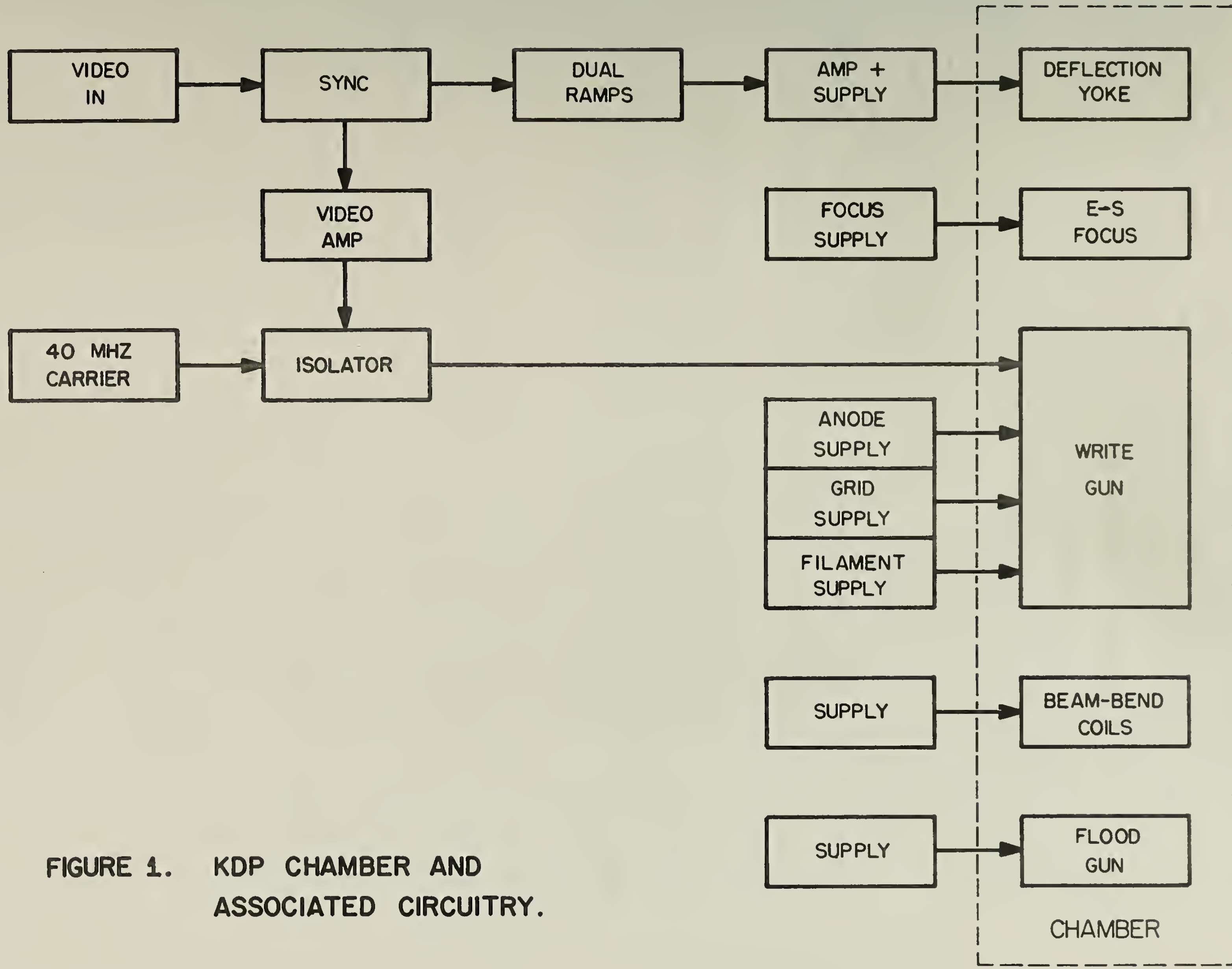


FIGURE 1. KDP CHAMBER AND ASSOCIATED CIRCUITRY.

2.2 Bandwidth Compression by the Delta Method (Project No. 14)

The Delta Method of bandwidth compression is to be applied to video television signals. Two successive frames of video information are to be compared and the information which has changed between these frames is to be detected. (Hence this method is referred to as the "Delta Method".) If a storage device is employed in the television receiver, only the changed information need be sent to up-date the stored information. Spreading this "delta information" out on the time scale would achieve bandwidth compression of the television signal. This project will be concerned with detecting the delta information and grouping the corresponding portions of the television signal together on the time scale, rather than actually compressing the bandwidth. This information will then be decoded and displayed on a television receiver.

The first phase of the project is to detect information using a multi-track video disc recorder. Each frame of information will be stored and compared with the succeeding frame, using a video NAND gate. The output of this gate will be the desired delta information.

D. C. Rollenhagen

2.3 Functional Encoding (Project No. 15)

Conventional TV systems (of the broadcast type) have a bandwidth requirement of 4.2 MHz, which allows a resolution of about 430 lines This 4.2 MHz bandwidth is used regardless of the complexity of the picture, whether it is a simple black and white line drawing or a complex scene containing several shades of grey.

Intuitively one would suspect that the simple line drawing could be transmitted over a bandwidth considerably smaller than 4.2 MHz. This leads one to look for a means of encoding line drawings in such a way that they can be transmitted over such a smaller bandwidth.

Suppose a line drawing is being picked up by a camera and displayed on a TV monitor as shown in Figure 1. The video signal from each of the 525 scans will have a transition at each intersection of the horizontal scan with the lines on the screen. A sample line of video is shown in Figure 2. The positive transitions indicate the intersections.

The elapsed time between these transitions can be encoded into voltage levels. These voltage levels would be transmitted at a rate of 15.75N kHz, where N is the number of functions to be transmitted. Figure 3 shows how a single scan line of video corresponding to a four line drawing ($N = 4$) is encoded. One can see how the elapsed time between intersections of the horizontal scan and the lines on the drawing are encoded into voltage levels spaced at $63.5/N$ μs intervals. The elapsed times between these intersections may be very small, and hence have a high frequency content in the original video signal. The encoded signal, however, does not have these high frequency signals.

Using this encoding scheme the bandwidth of the channel needed to transmit these line drawings is determined by the number of lines (or functions) being 15.75 kHz per line or function.

The decoding scheme is similar to the encoding scheme. The incoming information is stored on a scan-by-scan basis, and each stored scan is reproduced at high speed in order to regain the original high frequencies that were present.

Peter Oberbeck

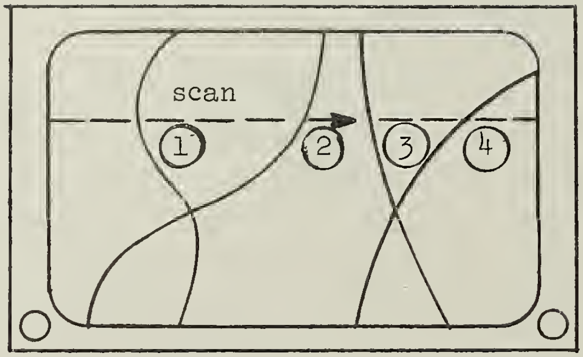


Figure 1. Line Drawing on TV Monitor with Sample Scan.

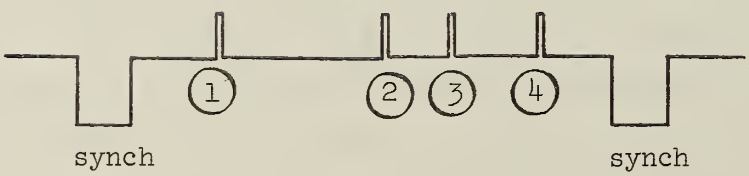


Figure 2. Video Signal from Sample Scan of Figure 1.

(a)

(b)

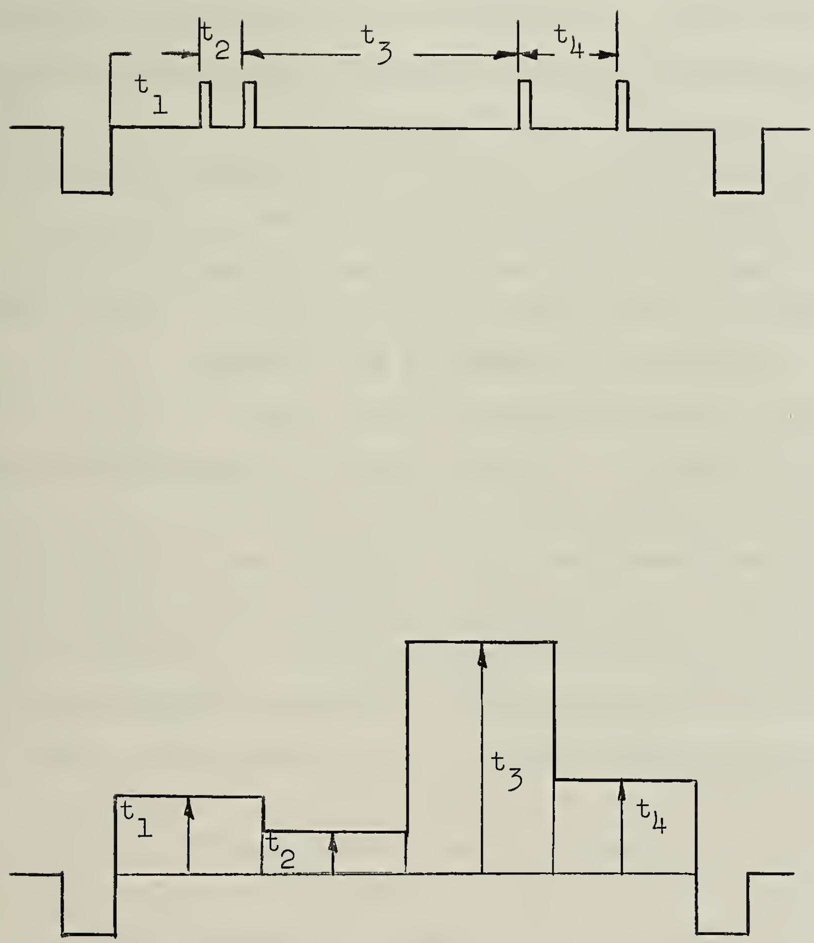


Figure 3. a. Video Signal

b. Encoded Video Signal

2.4 Automatic Tricolor Cartograph (Project No. 16)

2.4.1 Introduction

The Automatic Tricolor Cartograph is a graphical processing system which can perform certain simple operations in three colors and their combinations. The basic system consists of four parts: the display, the pen, the memory and the processor. The function of these parts is as follows:

The display is in effect the "drawing board" used by the operator. It continuously displays information which has been written into the memory by the operator or the processor.

The pen is used to write on the display, erase from the display and to designate operation points for the processor.

The memory stores the graphical information written into it by the operator or the processor and also provides readout which is presented to the operator by means of the display.

The processor performs coloring operations and writes its results into the memory. It has the capability of coloring in areas designated by the operator with a selected color.

Typical operations with the system are accomplished as follows: writing or erasing on the display is accomplished by simply pointing the pen at the appropriate area and pressing its activation switch after selecting the write or erase mode. Coloring is accomplished by selecting the appropriate color, indicating the area to be colored with the pen and operating its activation switch.

This system has potential uses in drafting, sketching, map layout and other related areas. In addition it can be used to define a pattern to be sought for by a pattern recognition machine. Through the addition of a digitizer on the output, the system can be made compatible with the input of a general purpose digital computer.

The system is unusual for a graphical display system in that it does not employ a digital computer. The operations within the system are accomplished by means of hybrid digital-analog circuitry.

2.4.2 Operation

The display is a standard 3 color television monitor. The face of the display tube is scanned by the electron beam at 60 cps vertically and 15,750 cps horizontally. The display is interlaced so that a complete scan is accomplished in 1/30 sec. The pen contains a photo diode which is sensitive to the light output of the display. Each time the electron beams pass the field of view of the pen, a pulse is generated from the light produced. This pulse is amplified and shaped and is used to write directly into the memory or to define a point for the processor.

The memory is a video disk recorder with standard video output. The three video outputs of the recorder are transmitted to the display where they appear for viewing. This type of memory has an advantage in that pictorial information can be stored for indefinite periods of time without regeneration. The use of a scan conversion tube wherein the functions of storage and readout are combined in one tube is also possible, but indefinite storage is not possible in this case without regeneration; and regeneration would degrade the information.

2.4.3 The Coloring Problem

One of the features desired in the system is the ability to color in selected areas of the display. This operation should be controlled by the processor to a large extent, if possible. In fact, it would be nice if the operator could designate an area on the display, press an appropriate button, and have the area colored in.

In order to accomplish this, the operator must communicate the following information to the processor:

1. Choice of color.
2. The area to be colored.

Implementation of the first of these is no problem since it merely involves a choice of track in the memory. The second is not so easily accomplished. The operator may be required to designate by means of the pen the interior of the area to be colored. For example, in order to color an area as shown in Figure 1, the pen will have to

traverse the paths shown in Figure 2. In other words, the area between the closest left and right boundaries will be colored in on any given stroke. If the figure to be colored is not closed on the side, the coloring will continue to the end of that line. The possible presence of cusps on the defining boundary presents an additional problem in the design of the coloring circuitry.

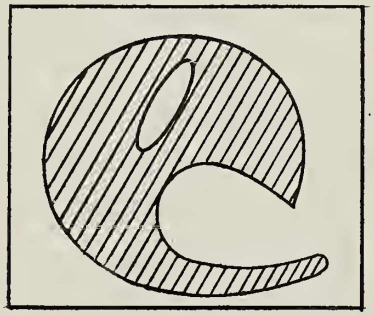


Figure 1.

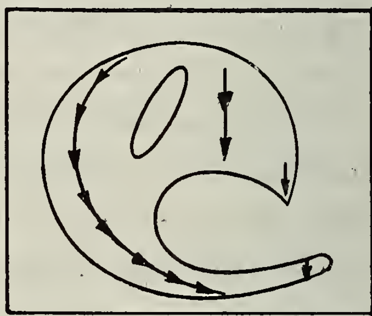


Figure 2.

2.4.4 Implementation

In order to accomplish the coloring, four tracks on the disk are employed. Three of these are for the three colors and one is the boundary memory. The latter stores the defining outlines for the coloring. In addition, a fifth prerecorded track supplies standard EIA sync to the system. At present it is envisioned that coloring will be accomplished by having an x counter that always stores the coordinate of the last boundary as the scan progresses. Upon receipt of a pen pulse, this coordinate set (x, y) is fixed and on the next scan coloring takes place between this point and the next boundary line. Clearly this is a relatively slow process since one scan is needed to define the area to be colored and one to accomplish the actual coloring. Because of this it is most desirable that a better method be found.

William Kubitz

3. COMPUTER SYSTEM SOFTWARE RESEARCH

(This work is supported in part by Contract No. AT (11-1) 1469 of the Atomic Energy Commission and in part by the University of Illinois.)

The format of this section of the Quarterly Report has been changed with this issue. Now, and in the future, the separate sections will be written, and attributed to, the people responsible for the work.

3.1 Time Sharing System

The principal developments in the existing system have been to increase the number of active consoles, and to finish modifications to the new Fortran and loader.

In preparation for the 360, work has started on a PDP-7 to 360 link and the design of an interactive compiler.

BOOTS

A. Fortran and Nicap were inserted into the system's time sharing environment, but neither work correctly. The basic problem involves sequencing from pass to pass within a translator with possible machine malfunctions tossed in. Fortran, as far as it has executed so far, works as it should, but no code has been compiled by it as yet. Nicap has coding errors involving disk accessing.

B. The relocatable binary loader was accommodated, but has not yet been inserted into its little niche in the system yet due to an incompatibility with the system. Since there is no code being generated by the translators yet for it to try a load, no great effort has been made to really try to get it working, at least from my standpoint.

C. The library loader was inserted into the time sharing environment, successfully to all intents and purposes, but a real check-out awaits the relocatable binary loader, which is the only program that uses the library. Superficial signs are that the library is loaded correctly onto the disk.

D. The disk allocation subsystem has been checked-out and appears to work perfectly. Disk tracks are handed out sequentially to whoever needs them

until the supply is exhausted, then tracks are obtained from the linked list of previously used but presently available tracks, which list is being continuously built by the same subsystem as files are released by their users. Recovery from shoot-downs appears to work perfectly, with the allocation subsystem able to determine precisely where the next free track was and what the status of the free linked list was at the time of the shoot-down.

Recovery from a shoot-down is accomplished in the following way. Whenever a record of data is written on the disk a second record is written on the short-record portion of surface 0 of the same cylinder and module. This extra record contains all the status information pertaining to the disk: where the next free track is on each module and where the linked-free list stops for each module, together with how many sequential tracks are available, if any, and whether a given module is handing out tracks sequentially or has switched over to using the free linked list. Each one of these extra records also contains a counter, which is increased each time such a record is written. Thus at all times the surface 0's of all the cylinders on all modules contain a jumbled history of the disk use (not a complete history as previous status information gets overwritten periodically whenever a track on that cylinder and module is used) and the short-record with the highest counter is the current state of the disk. To recover from a shoot-down a search is done of all short-records of this type and the one with the highest counter is assumed to be the current state of the disk and is used to restart the system. The search of the 250 pertinent short records per module takes about 35 seconds. No extra time is wasted while running by the writing of the extra records as no seek is needed and the extra write is done in the same revolution of the disk as the data record write.

E. An automatic error recovery procedure was inserted in the system making use of high-core features already present. In the event of an error (parity, protected memory violation, etc.) high-core automatically swaps block 200 of the drum into core block 0 and transfers to location 0. The code thus swapped in brings in more code from the disk, then dumps, in octal, the contents of core and the contents of the time-sharing portion of the drum out onto tape 8 together with a message describing the error, then a complete reload of time sharing is attempted. If the reload fails everything dies. Future improvements include the facility to reload only that portion

of the system involving the error in the following sense: if console 3 develops an error only console 3's data will be clobbered--all other consoles would continue as if nothing had happened. At present all consoles are reloaded.

F. A round-robin scheduler was added giving all consoles with running core loads a 5-second slot of execution time. Overhead, with more than one console running, is 3 seconds per swap. Disks are very slow.

Current work involves getting Fortran and the relocatable binary loader to work. This accomplished, no further work is contemplated.

L. Greninger

Compilers

A. The final modifications were made in Fortran to enable it to run on the T. S. system. Pass II and Pass V had code added to leave a five word information table for the T. S. system when the compiler is finished due to either fatal errors (Pass II) or completed compilation (Pass V).

Shortran, having been dumped in my lap in an unfinished state, was worked on. Several of the subroutine calls were changed to the correct format. A modification was made in the routine to calculate double subscripts, and one made in the format decoding routine.

In addition, many of the more basic routines were flow charted in detail; specifically, the character manipulation routines, the buffer packing and unpacking routines, the point routine, and the message routine.

B. Work was initiated on a console compiler for the 360 system. It was decided to implement a version of PL-1 which will be numerical-programming oriented.

Specifications for the nature and organization of the routines involved were outlined.

J. L. Christopher

Loader

Since the time sharing system has been simplified by using BOOTS, I have made revisions in the loader to conform to BOOTS. In the present version, the loader is given one table A which is 20 words long and starting at 4076 dec. It is a table of disk dictionary addresses, all files of which are loaded in order given by the loader. The table is considered ended when either the first 0 is found or 20 addresses are used.

After all files are loaded, all undefined names in the call-entry table are checked to see if they exist in the library. The format of the library (on disk) conforms to the description in Memo No. 46. The TDE's (typical dictionary entries) are read and compared with the unknown name. When a match is found, the 4th word of this TDE gives the address of the binary copy of the library routine. This is loaded and other subroutine names are entered into the C-E table. If a name remains undefined, an error is printed.

The loaded program is placed on the drum in segments of 2K and execution returns to the monitoring program.

M. A. Berg

Satellite Connections

A. The PDP-7 satellite processor program was rewritten and is currently in use. The new version allows up to 32 consoles to be processed and provides users with automatic tabulation and line numbering. Full use is made of the automatic telephone line connect-disconnect feature recently installed in the 630 data communications adapter to the PDP-7. Use of this facility ensures protection of user files when console operation is terminated without the proper logout sequence.

B. A 16 bit plus parity high speed work transfer channel was designed to link the PDP-7 to the IBM 360 mod 50, 2701 parallel data adapter. This channel will be installed in the PDP-7 and will be in addition to the currently operating SPU channel to the ILLIAC II.

C. Work was done in regards to providing a working system for use of the analog-digital facility of the ILLIAC II.

A. Otis

3.2 Graphic Programming System

Additional delays in the delivery of the 338 system are being encountered. Currently we are being quoted a May delivery.

Planning

The software to check out the communication link between the PDP-8 and the PDP-7 was completed this quarter, and it was utilized to the extent that the console teletype of the PDP-8 can be used as a time sharing console in the ILLIAC II time sharing system. With the delivery of the rest of the PBD-338 this program can be converted to using the scope for output instead of the teletype. This allows the user to have a faster means of output, thus more flexibility.

The software has been planned and partially completed to allow a user to display on the PBD-338 using routines similar in terms of basic function to those used for the CalComp plotter. This allows a user to code check his programs and their plotted results very quickly in a time sharing mode and then with the switch of a subroutine have his results plotted on the CalComp for hard copy permanent results. This facility can be used for the production of animated drawings and some structured systems analysis. In the planning stage are routines to allow the user to draw on the display face and then read in ILLIAC II the end coordinates of the line approximation to his drawing.

This would allow a user to input the partial graph of a function and have his routines in ILLIAC II do calculations based on the input graph. The completion for this software is scheduled for the coming quarter.

The planning and implementation of the Graphical Programming Language Project is now in the following state: the description of the software and the operational aspects of the system for the PBD-338 is stabilized and is now being. prepared as a separate file. The coding and checkout of these programs will start in the next quarter.

The planning in the next quarter will be on what capability the Graphical Programming Language is to have and what is needed in the language sense to process this Graphical Programming Language.

F. K. Richardson

Direct Plot Output

A plot routine to format the transmit data to the 338 display unit was written and debugged on the ILLIAC II. This routine uses the same calls as those used for the present CCP1PL routine for the plotter. A call to CCP1PL with X and/or Y parameters off the screen results in an error message and termination of the user's program.

An alternate version to the above program which would permit the user to "draw off the screen" has been written and is currently being debugged. In this program, if a move which would be off of the screen is given, the plot is made to the edge of the screen, point off the screen is saved, and when a move again enters the screen, the line is drawn from where the line would enter to the specified point.

Some planning has been done for the preparation of a SYMBOL routine for transmitting symbols to the 338. This will correspond to the CCP2SY program except that rotations of the characters will not be permitted. Coding of this program should begin in the near future.

L. L. Koopman

Display Programs

Programs have been written to handle teletype input/output on the PDP-8 and to track the pen on the 338 display. The latter cannot be fully debugged until the hardware is delivered.

T. Y. Lo

3.3 Automatic Solution of Ordinary Differential Equations

A paper describing the state of the system last June was presented to the National A.C.M. Conference in Los Angeles. Since that was written, the problems associated with stiff differential systems have been investigated, and current work is concentrated on incorporating features to deal with these problems into the system.

A report on stiff equations has been written, and will be distributed shortly.

C. W. Gear

Compiler Section

My specific project is a compiler which is to be used in an interactive Ordinary Differential Equation (ODE) solver, a version of which is already working on ILLIAC II. The major alteration which I am making to the existing compiler is the addition of partial derivatives.

The ODE solver consists of three segments:

Segment 1 - A dialogue program to "talk" with the user either via remote console or via batch process, which obtains the following information:

1. a list of the differential equations to be solved simultaneously
2. the initial values
3. order of the method desired
4. the interval of integration
5. error limit
6. the step size (variable or fixed)
7. output format and selective print option
8. plotter option

Segment 2 - A syntax oriented compiler which "reads" the lines and puts the equations into syntax form.

Segment 3 - The integrator, a group of routines which integrate, iterate, change the step size if necessary, etc. and finally output the results.

One of the common methods of exhibiting the structure of statements is by classifying them through Backus Normal Form. The data or source language statements of the ODE solver's compiler form a sequence of lines each of which is composed of a statement or an equation, etc. The input to the ODE system has the syntax:

<SEQUEN>::=<LINE>|<LINE>,<SEQUEN>

<LINE>::=<STMT>|<EQUATI>

<STMT>::=<VAR>=<EXP>

<VAR>::=A|B|C|D|E|...|V|W

<INDEP>::=X

<DEP>::=Yi|Y|<DIFFSE>   where i ::=1|2|3|...|9

<DIFFSE>::='|'<DIFFSE>

<EQUATI>::=<DEP>=<EXP>

<EXP>::=<TERM>|<TERM>+<EXP>|<TERM>-<EXP>

<TERM>::=<FACTOR>|<FACTOR>*<TERM>|<FACTOR>/<TERM>

<FACTOR>::=<PRIMAR>|<PRIMAR>**<FACTOR>

<PRIMAR>::=PI|<INDEP>|<DEP>|(<EXP>)|<VAR>|<CONST>|<FUNCT1>(<EXP>)|
<FUNCT2>(<EXP>,<EXP>)|<PI>

<FUNCT1>::=SIN|COS|EXP|SQRT|ATAN|ABS|LOGE|LOGT|LOGB

<FUNCT2>::=MAX|MIN

<CONST>::=some conglomeration of numerals and "." uses READEC of PRINT subroutine.

Note: PI stands for 3.14159.....

The present system compiles function subprograms for the numerical integration package. It is to be modified to also produce the partial derivatives of the functions w.r.t. the dependent variables.

C. A. Ellis

Numerical Methods

A particular numerical method has been studied in detail. The technique investigated had been shown to be stiffly stable for methods of degree six and lower. The program was designed to extend this procedure up to methods of degree twenty in order to determine whether it was stable for methods of degree greater than six.

Specifically, the following ratio of two polynomials:

$$\frac{\sum_{q=1}^{K} \alpha_q (Re^{i\theta})^{q-K}}{\sum_{q=1}^{K} \beta_q (Re^{i\theta})}$$

was evaluated for different values of θ, $0 \leq \theta \leq 2\Pi$.

The β_i are read in as guesses and the α_i are generated from the β_i so as to make the multistep method using the α and β of degree K. Then the corresponding values were plotted in the complex plane.

However, the resulting graphs failed to show any significant region of stability for methods of degree seven and greater.

K. Walsh

4. ILLIAC IV

4.1 Introduction

4.1.1 Summary of Major Results

During this quarter we have concluded our experiment on optimal utilization of insufficiently fueled, low performance aircraft. It must be reported that the results have been less than gratifying.

4.1.2 Design

What would appear to be the final round of major system perturbations appears to be nearing conclusion. In the PE it was decided that extensive (multiply and divide) 8-bit instruction sets are impractical, thus at the 8-bit level a rich set of logic orders and a small set of arithmetic orders will be provided. Moreover, these will not be mode controlled down to the 8-bit level. Programming experiments indicated that the penalties are not so severe as to make 8-bit codes unappetizing. At the other end of this spectrum, multiple floating point precision looks okay, i.e., there are no apparent ghastly design errors which make it hard to program efficiently.

Work on the CU design has really just begun in earnest and the next Quarterly Report should possess some decent facts.

4.1.3 Maintenance

Some tentative approaches to system maintenance have been formulated and are reported at length in this report. There is at this time no meaningful calculations of system failure rates. Such a calculation must be made at the earliest moment at which there is meaningful date to utilize.

4.1.4 Software and Applications

The application work continues to offer great encouragement. In this report are included good material on handling sparse matrices and reasonably complex Partial Differential Equations.

In the section on seismic array signal processing, the two principle filter design techniques are discussed in a nondefinitive but highly encouraging way.

4.1.5 Administrative

The principle concern here is, of course, the execution of a decent contract with Burroughs and in turn the execution of a contract between Burroughs and Texas Instruments. It would appear that the execution of a contract with Burroughs on a straight fixed price basis is not in the cards and also that the factor 16 or so improvement in performance objectives for the system since the initiation of the contract will be mirrored by factor two increase in major program costs. The formulation of incentive formulas is the principle difficulty.

As to the internal project organization, all that can be said is that during this reporting period it received an excellent test which it passed so well as to be a major source of irritation to the Principal Investigator.

4.2.1 ILLIAC IV Reliability Analysis

The number of gates in ILLIAC IV (approximately 3×10^6) urges serious attention to problems of reliable operation. The use of integrated circuits reduces the reliability requirements per gate; it is similarly expected that the hybrid packaging of chips will further improve performance.

Several reliability models are being analyzed in order to estimate levels of component reliability which must be obtained. In addition, procedures for testing of the initial circuits are being examined to permit earliest assessment of the actual reliability expected from the ILLIAC IV components.

4.2.2 System Error Detection

The problem of devising error detection features for ILLIAC IV programs has been addressed from three more or less conventional viewpoints:

(1) Back substitution

(2) Repetition

(3) Exhaustive exercise.

In the back substitution approach, values which may be in error are substituted into intermediate equations of the program and the equations are examined to see if they are satisfied. This method will detect both systematic errors (errors which consistently occur due to a hardware failure) and transient (one time) errors.

The repetition approach performs the calculations for a set of equations several times and then compares the results. A disagreement in results will signal that a transient error has occurred. Since the same algorithm is used for each repetition, this approach will not detect systematic errors.

The exhaustive exercise alternative calls for frequent pauses for error checking by the execution of a program which uses all units of hardware to produce a known result. The detection program may be especially written for the purpose or could possibly be a production problem of sufficient complexity. This method will trap systematic errors, but can miss transient errors which may have affected the results of a production program.

Programs which are not amenable to the back substitution approach will require the use of both of the other two approaches to insure the detection of both systematic and transient errors.

4.2.2.1 Check Point

For the computation which takes time close to or more than $\frac{1}{K}$ times the MTBF, an ordinary check point system also is applicable: the contents of the PEM and PE registers are dumped into the DISK at predetermined intervals ($T/n < MTBF/K$) followed by hardware exercises. When the exercises show no fault in the ILLIAC IV, the computation is resumed; otherwise, the older copy of memories and registers are used to restart the computation after the fault is repaired.

If we divide computation time T into n intervals, the extended computation time T', due to the exercise and rerun, will be:

$$T' = 1 + \frac{nT_x + T}{T/K} \quad T_x + T/n$$

where T_x is the time required for exercise (including load and dump time) and T is MTBF. The choice of n to minimize T' is given by:

$$n = \frac{T^2}{T_x} \quad 1 + \frac{T_2}{T \times K}$$

In both equations an integer K is selected so that the system is checked several times before the probability of success (no failure)

falls below a predetermined threshold value corresponding to an operating time of MTBF/K. The MTBF will be calculated using a Poisson distribution (n = 0) until the appropriate Weibull distribution coefficients have been determined through component testing and/or system operating experience.

4.2.2.2 Fault Location

The fault location program will identify the particular subsystem in which the fault occurs. It will then select and initiate the diagnosis program for the subsystem.

The fault location program tests one subsystem at a time using a set of previously tested subsystems. This procedure is initiated by the GPC which can be tested by usual maintenance routines.

An example of the procedure is shown in Figure 1. This procedure tests subsystems in the following order:

(a) Memory subsystems (DISK, PEM)

(b) Control subsystems (IOC, CU)

(c) Processing subsystems (PE).

This order permits the upper subsystems to be involved in testing of the lower subsystems.

The following is the description of testing at each stage of the procedure.

Stage a. GPC Test

GPC testing is done by regular GPC maintenance routines.

Stage b. IOC-DISK Test

This testing is done by the GPC. ILLIAC IV is shut down or some means is provided to ignore any ILLIAC IV signals to avoid unnecessary disturbances in the testing.

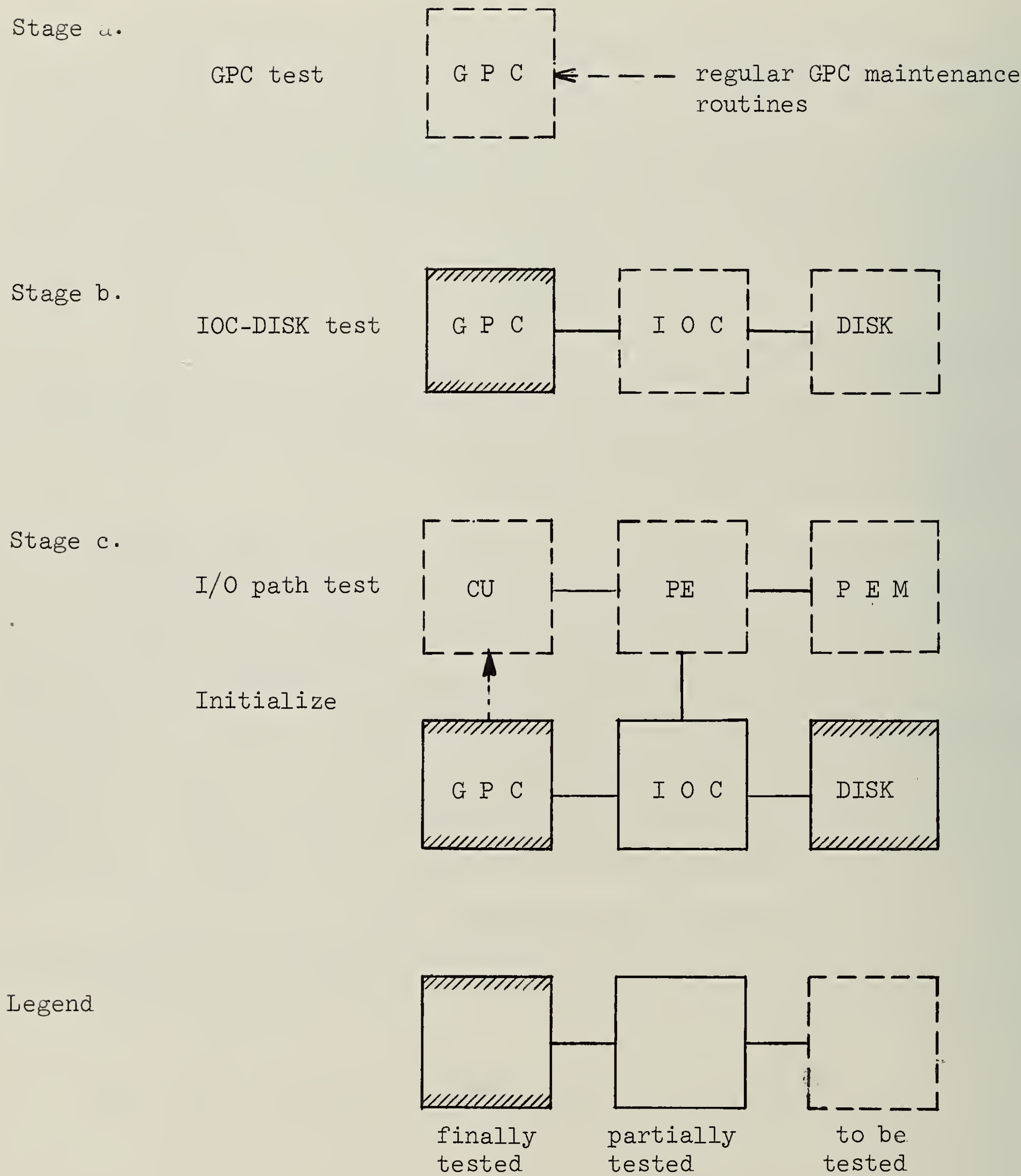
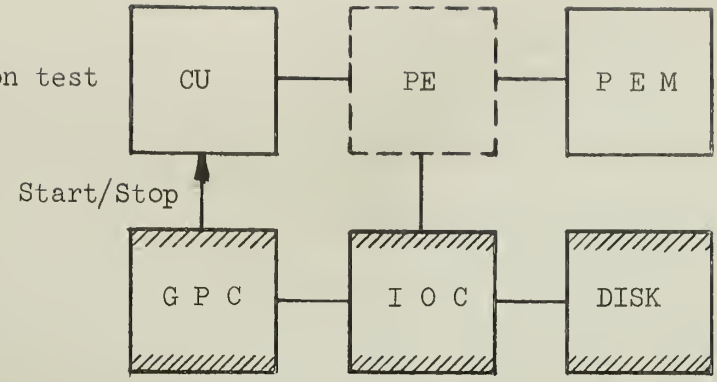


Figure 1. A Fault Locating Procedure.

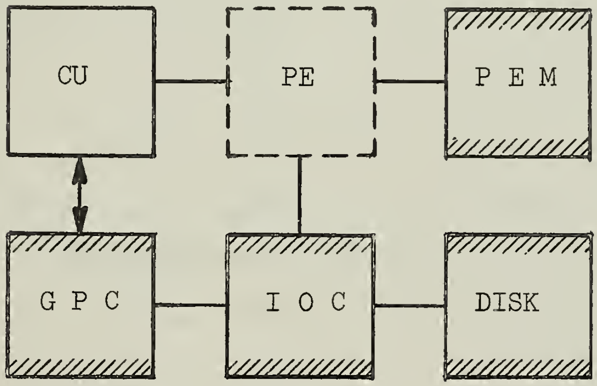
Stage d.

Basic CU function test



Stage e.

PE test



Stage f.

Multi-quadrant test

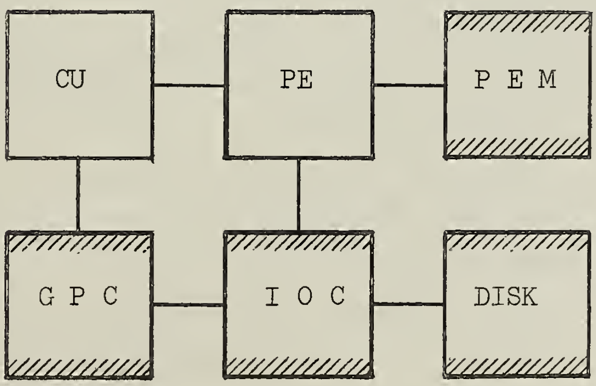


Figure 1 (Continued). A Fault Locating Procedure.

Stage c. Input/Output Path Test

The Input/Output path is tested by the IOC and the GPC. The ILLIAC IV is in initialized status and is not running.

Stage d. Basic CU Function Test

The GPC-CU control communication (start, stop and interrupt) and decision (skip instruction) functions are tested first. Then all addresses of PEM and local memory are tested with a small number of instructions, which can be accommodated in the 64-word instruction buffer. CU instructions relating to CU accumulator are also tested.

All four CU's are operated independently and tested simultaneously. Instructions requiring multiple array operation are tested at final Stage f.

Stage e. PE Test

After they have passed Stage d, the PEM and the CU will be ready for use during the PE test programs of considerable complexity. The PE and the CU logic concerned in PE instructions are tested at this stage.

PE decision ability is first tested against the CU decision. Once this is proved, decisions regarding further test results are turned over from the CU to the PE; that is, tests are done by all PE's simultaneously.

Major categories of PE testing will be as follows:

(a) Routing paths
(b) Register--register paths
(c) CU--PE paths
(d) Arithmetic operations
(e) Shift and logical operations
(f) CU--PE control communications.

Stage f. Multiquadrant Operation

So far four quadrants are operated independently. Hardware regarding inter-quadrant data and control communication is tested at this stage.

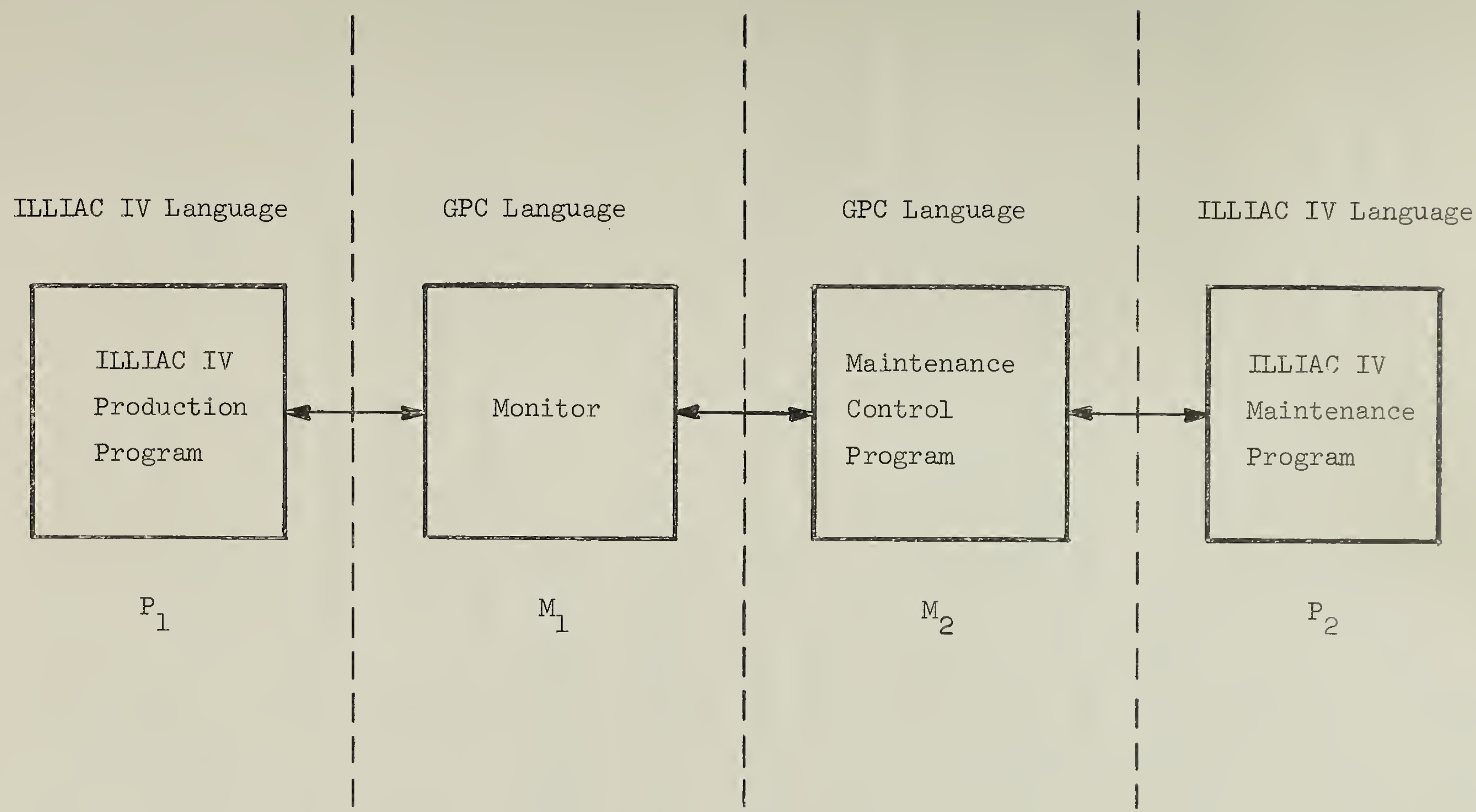


Figure 2. Maintenance and Production Program Transition.

4.3.1 Introduction

The simulator effort has been successful in keeping up with the specification of ILLIAC IV. PE and memory simulation being well under control, the CU simulator awaits design decisions.

The operating system has been given a small amount of initial thought, particularly with respect to its influence on the choice of the Input/Output computer.

The language design, translator construction effort has mainly been centered on the data structure problem. Since a vector-matrix oriented language seems desirable, the question of laying out such arrays in the ILLIAC IV memory has been studied. If the matrices are dense, we conclude that the software can automatically handle storage allocation. Sparse arrays will require some detailed analysis by the user. Statements will be provided for the mapping of such arrays into memory. Then the software will be able to handle indexing problems.

4.3.2 ILLIAC IV Simulator System

4.3.2.1 Summary of Progress

The design and construction of the ILLIAC IV Simulator System is well on its way to completion. To the extent that the machine has been designed, much of the programming is completed.

For a basic description of the system and its objectives, the reader is referred to the Second Quarterly Progress Report. With two exceptions, that description remains intact. The exceptions are (1) the assembler program was to be coded in FORTRAN II but is, in fact, being coded in MAD, and (2) the PEM (processing elements memory) layout on the 1301 disk module has been modified slightly. Details of these changes may be found in the next section.

Programming for the simulator system has been divided into sections as represented by the following outline.

I. Assembly code translator
   A. Language definition processor
   B. First translation pass
      1. Construction of symbol tables
      2. Macro definitions processor
      3. Expansion of macro instructions
   C. Second translation pass
      1. Instruction identification
      2. Pseudo operations processor
      3. Variant bits construction
      4. Symbol search and translation
      5. Diagnostics

II. Machine simulator
   A. PEM buffers accounting
      1. Construction and depletion of request queue
      2. Emergency override of request queue
      3. Buffer allocation and bookkeeping
   B. Executive control
      1. Look-ahead to find request queue entries
      2. Program flow control
      3. Instruction buffer maintenance
   C. Instructions simulation
      1. PE driving instructions
      2. Non-PE driving instructions
      3. Pseudo Input/Output instructions

Table I indicates progress in these areas to date.

TABLE I

Design		Code		Debug	
Begun	Complete	Begun	Complete	Begun	Complete
I.B.1.	I.C.1.	I.C.4.	II.C.1.	II.A.3.	I.A.
I.B.2.	I.C.3.	II.C.2.			II.A.1.
I.B.3.	II.B.1.				II.A.2.
I.C.2.	II.B.2.				
I.C.5.	II.B.3.				
II.C.3.					

The next section is a technical discussion of decisions made and work done during the preceding quarter.

4.3.2.2 Technical Discussion

A format for the assembly language has been designed and its description distributed to the applications programmers. Syllabic machine instructions are represented one on a line and the line is divided into four fields. Since the syllabic format is a generalization of the single format approach, the present scheme may be used with any of a variety of formats which may be chosen.

Line Positions	Information Contained
1 through 6	symbolic location
8 through 13	function code mnemonic
15 through 22	operation modifier mnemonics
24 till blank	operand

The symbolic location field serves to assign symbolic names to PE memory locations. Only those lines (i.e., bytes) which are to be addressed need be assigned a name.

The function code mnemonic field is self defining. There is a one-to-one correspondence between the allowable mnemonics and the first syllables of the machine instructions.

Operation modifier mnemonics serve to further specify, when applicable, the operation represented. These modifiers represent variant bits in other than the first syllable. Modifiers are separated by commas.

The operand field contains symbolic or literal operands. Symbolic and literal number notation may be used to specify CU (control unit) or PE memory addresses; CU memory addresses are defined by declarative pseudo-ops. Certain operands such as shift counts, bit numbers, etc., are specified only by literal numbers.

Symbolic operands are one to six characters and begin with a letter. Literal numbers are written as "numerical digits (base)." If "base" is not specified, ten is assumed, e.g.:

$$77(8) = 111111(2) = 63$$

An asterisk immediately following an operand indicates that the operand is to be indexed by the indices. The random instruction samples of Figure 1 show how source code for the assembler may look.

Symbolic Location	Operation Mnemonics	Modifier Mnemonics	Operand
START	RNN	N	
	INR	X,D	
HERE	SAP		
	LDD		DATA*
	SHIFT	R	8
THERE	SLIT		10101100110111101001(2)

Figure 1.

Machine instructions are from one to nine syllables, eight bits to a syllable. The first syllable of an instruction is the identifying function code. If there are more syllables, they contain bits of the types listed below.

N a bit which is not used for instruction decoding

A a bit which (a) is defined in the operand field
(b) refers to a PEM address
(c) may be represented by a symbolic name

C a bit which (a) is defined in the operand field
(b) refers to a CUM address
(c) may be represented by a symbolic name

L a bit which (a) is defined in the operand field
(b) refers to a literal number
(c) is represented by numerical digits

V a bit which is defined by an operation modifier

X a bit which controls operand modification by PE indices.

Assuming the format as presented, it is possible to write an assembler without fixing mnemonics, and furthermore, without fixing the machine instructions as well. Data cards of the type shown in Figure 2 may be read into skeletal table structures at execution time. These cards fully specify the legal source code of the programs that follow. It is useful to be able to alter a language from day to day when operating in an unfrozen design environment such as ILLIAC IV will be for some time.

The PEM symbol table is constructed by assigning names, found in the symbolic location field, to corresponding memory addresses. CUM and additional PEM addresses are assigned names in their respective tables by data defining pseudo-ops. Subroutines to sort and to search these tables and the translation tables generated by the language read-in phase have been coded and debugged.

Machine instructions for ILLIAC IV are micro in nature (e.g., an ordinary unconditional transfer of control requires two machine instructions). Under this circumstance, defining often-used instruction sequences as macro instructions is desirable. Figure 3 illustrates

```
 ┌──────> Syllable number
 │    ┌─────> Function code mnemonic
 │    │   ┌─────> Function code (octal)
 │    │   │              Operation modifier mnemonics
 │    │   │                    ^
1--RNN-120                     │
2-VVVVVVVV-1(A,B/D-A,D/B),2(A,B/D,M-A,D/B,M),3(N,E/S,W-N,S/E,W)
1--SHA-100
2-XVLLLLLL-1(L/R)
1--STO-150
2-XNVVAAAA-1(A,B/D,X-A,D/B,X)
3-AAAAAAAA
     └────> syllable formats
            a)  mnemonics/mnemonics ≡ reset/set ≡ 0/1
            b)  sets (a) appear left to right by order of V bits
            c)  for construction N (group), N is position number in modifier field
For example:

            | RNN   | A,B,N |          ==>  01010000  00010000
            | SHA   | L     | 32(8)*   ==>  01000000  10011010
            | STO   | D     | SYMBOL*  ==>  01101000  1010AAAA  AAAAAAAA
                                ^                                 ^
                                └──────── symbol table entry ─────┘
```

Figure 2. Assembly Language Definition Input.

Definitions:	CUAC	CU accumulator register
	CUX	CU index register
	nnnnnn	CU memory address of instruction counter
	Pi	the ith parameter to the macro expansion
	( )	implies "contents of"
	_	underscored characters trigger expansion

a)

	P_1	GO		P_2	comments
generates	P_1	SLIT		P_2	$P_2 \rightarrow$ (CUAC)
		STL		nnnnnn	(CUAC) + (CUX) $\rightarrow$ (CUX)

b)

P_1	P_2	P_3	$P_4(P_5)$	
P_1	LDL		P_5	$(P_5) \rightarrow$ (CUAC)
	XCU			(CUAC) + (CUX) $\rightarrow$ $\rightarrow$ (CUX)
	P_2	P_3	P_4	

a) defines a transfer of control macro

b) defines symbolic indexing of address fields by local registers

	GO		THERE
	SLIT		THERE
	STL		nnnnnn

HERE	GO		THERE(I)	
HERE	LDL		I	implies b) is of greater priority than a)
	SLIT		THERE	
	STL		nnnnnn	

Figure 3. Macro Definition and Expansion

macro definition and expansion within the format of the language. To compensate for ILLIAC IV's changing design and to provide flexibility to the programmers, a facility for run time macro definition will be provided.

Some of the functions performed by the assembler's second pass have already been discussed. Those of instruction identification and variant bit determination are shown by examples in Figure 2. Symbols are looked up with the binary search subroutine previously mentioned. There has also been some thought given to pseudo operation definition, particularly data defining pseudo-ops. Figure 4 illustrates how these may eventually appear in code.

As mentioned in the summary, most coding for the assembler and the simulator has been done in MAD (Michigan Algorithm Decoder). The MAD language provides many machine oriented operations and data structures which have been found convenient. For extremely machine oriented operations, where coding in any compiler type language would be a burden (or impossible), the machine's own language has been used.

Turning now to the simulator, among the early design decisions made was that of PEM layout on the 1301 disk. It was decided that a convenient record block size would be sixty-four ILLIAC IV words.

$$\frac{\text{PEM size}}{\text{number of tracks available}} = \frac{\text{624248 words}}{\text{10000 tracks}} \approx \frac{\text{64 words}}{\text{tracks}}$$

A PEM block is defined as a square group of words spanning eight long words in the vertical direction and eight PE's in the horizontal direction. Figure 5 shows how blocks are uniquely addressed in PEM and on the disk. Record blocks defined this way provide efficient coverage of large data arrays with respect to most groups of operations on these data. Furthermore, adjacent PEM addresses are likely found in the same cylinder, and instruction buffer fetches are done horizontally on these same eight-word boundaries.

Subroutines to fetch and store these blocks on the disk have been coded and debugged. These are machine language programs. The first subroutine enters requests in a queue and methodically empties

(1)	"symbol"	DEFINE	PEM	"literal
			CUM	
(2)		CONST	F	"literal"
	"symbol"		H	-"literal"
				"float. point"
(3)		CHAC	SET	"literal"
			INC	
			INT	
(4)	"symbol"	RESERVE	W	"literal"
			H	
			B	

Multiple line definitions indicate alternative entries for the field in which the multiplicity occurs.

(1) DEFINE equates a symbolic name with a PEM or CUM address;

(2) CONST places a full or halfword constant in the object code;

(3) CHAC (Change Address Counter)

a) SET $\Rightarrow$ "literal" $\rightarrow$ (AC)

b) INC $\Rightarrow$ (AC) + "literal"   (AC)

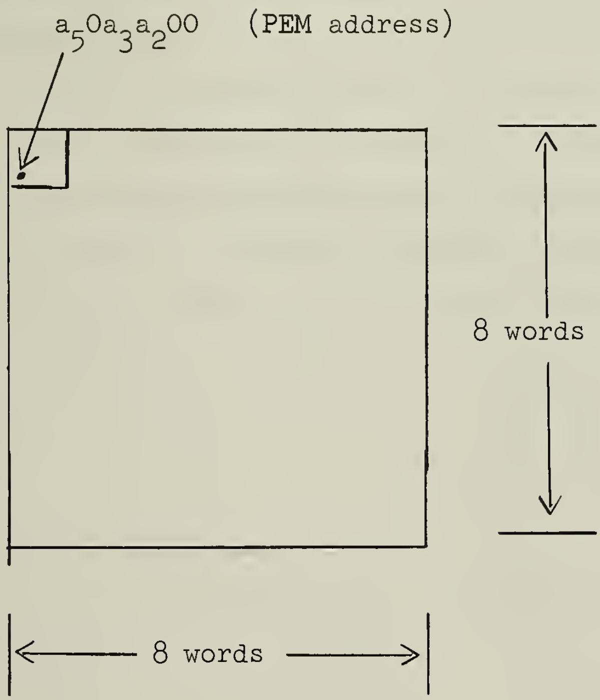
c) INT $\Rightarrow \dfrac{\text{(AC) + "literal"}}{\text{"literal"}} \times$ "literal" $\rightarrow$ (AC)

(4) RESRVE equates a symbolic name with the (AC) and then (AC) + "literal" $\rightarrow$ (AC).

Figure 4. Pseudo Operations

PEM byte address $a_5\ a_4\ a_3\ a_2\ a_1\ a_0$

a_5	a_4	a_3	a_2	a_1	a_0
8	3	2	3	3	3



$$\text{disk address} = D(a_5, a_3, a_2) = a_2 + 2080a_3 + 8a_5$$

Figure 5.

this queue in a first in/first out manner. Requests are added to the queue by means of subroutine calls, and the queue is emptied by initiating the next oldest request after each interrupt signalling "previous request satisfied." The simulator uses this routine in anticipation of accesses to PEM. However, there are certain to be many instances when the simulation of instruction execution is stalled waiting for a particular disk access. In order to insure that the next disk access made will be the one which allows the simulation to continue, a second subroutine, when called, overrides the queue process by performing a specified access immediately. It also alters the queue, if necessary, to reflect what has been done.

In order to minimize simulator dead time (i.e., the time when the simulation must halt and wait for a disk access), a look-ahead and request scheme has been designed (Figure 6).

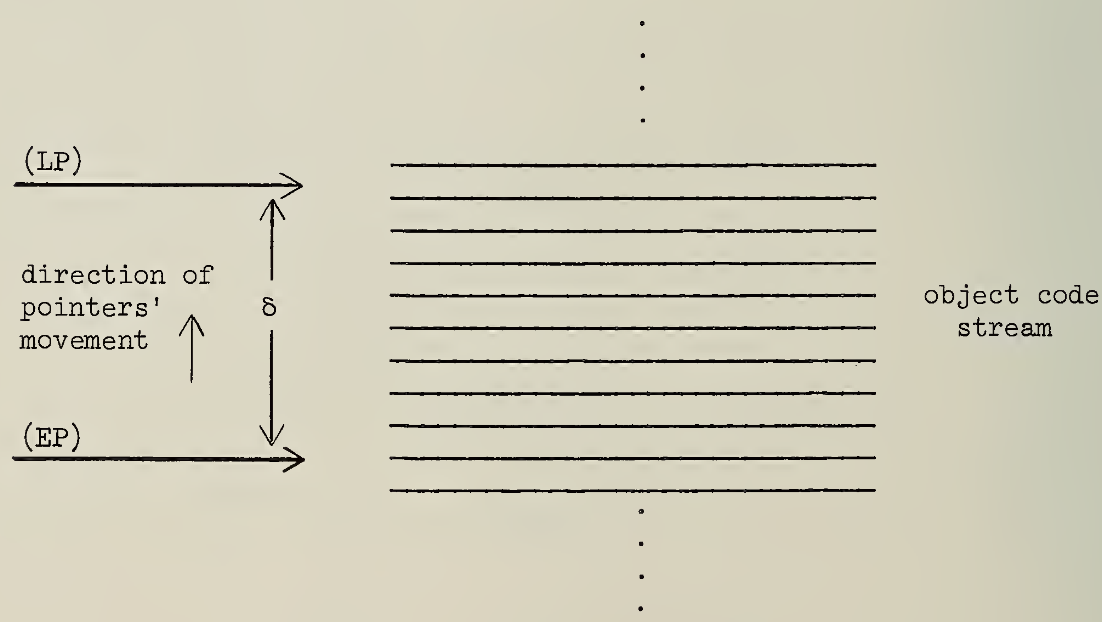


Figure 6

Code is examined at both the look-ahead pointer (LP) and at the execution pointer (EP). δ is the number of bytes between pointers. Data requests are made for PEM (disk) accesses on information obtained by the (LP) scan. The contents of the simulated memory and of the registers are changed by activity at the (EP). When the (LP) identifies a transfer of control instruction, the following steps occur:

(a) (LP) halts and $\delta \rightarrow 0$

(b) (EP) halts, (LP) continues, and $\delta \rightarrow \delta_{max}$

(c) (EP) continues

The look-ahead process just described and the simulation of the instruction buffer constitute what has been called, executive control. The executive has been designed in detail for a single quadrant.

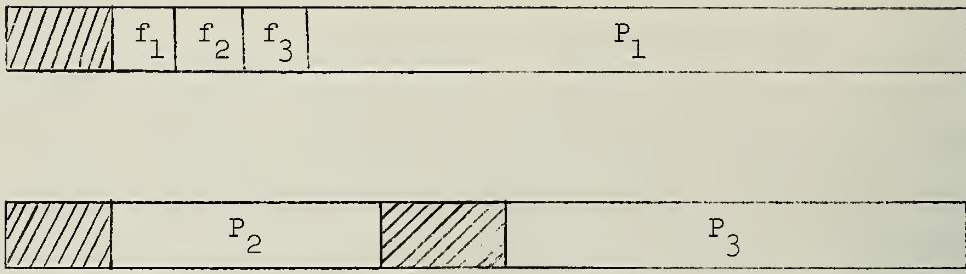
Between the executive control logic and the disk input/output queue there must be important interface logic to allocate and keep track of buffer blocks. Each buffer consists of 128 data words (64 ILLIAC IV words) and the two control words depicted in Figure 7. An estimated 110 to 130 such buffers (i.e., about 2 percent of PEM) will fit in 7094 core along with the simulator program. The control word information for each buffer, together with a short history of the latest instruction addresses from which requests were made, constitute the data for an allocation algorithm. This algorithm and the clerical logic to perpetuate it have been coded as a MAD subroutine. The routine is currently in the debugging stage.

The single remaining simulator topic is that of instruction simulation. The state of the machine is considered defined by the contents of its addressable registers between instruction executions. Therefore, the simulator does not reflect intermediate hardware states, and instruction simulation need not proceed in a manner analogous to the ILLIAC IV's hardware.

Most of the PE instructions (i.e., those instructions which are executed in part by the enabled PE's) have been coded. Those non-PE driving instructions which do not involve quadrant coupling

(CW1)i

(CW2)i



P_1 is one of the following:

a) the (LP) value at the last request for P_3

b) the (IP) value at the last access or store on P_3

P_2 is the $D(a_5, a_3, a_2)$ associated with the latest write from buffer a)

P_3 is the $D(a_5, a_3, a_2)$ currently assigned to buffer a)

f_1 is true if unfulfilled read request has been made on buffer a)

f_2 is true if unfulfilled write request has been made on buffer a)

f_3 is true if record P_3 has been changed since read from disk.

Figure 7. Buffer Control Words

4.3.3 ILLIAC IV Matrix Methods

4.3.3.1 Introduction

The occurrence of matrix operations in a wide range of areas prompted the study of storage allocation and programming problems for matrices in an effort to aid in the design of ILLIAC IV and in the formulation of a higher level programming language for ILLIAC IV.

The study of matrix storage, multiplication, and inversion for real and complex matrices and of storage of sparse matrices yielded some significant results.

4.3.3.2 Storage and Multiplication of Dense Matrices

The arrangement in memory of a matrix is of major importance with regard to the development of matrix operation algorithms. The best method for storing a matrix considering the criteria of program speed, storage efficiency, and storage compatibility of the various standard matrix operations, is termed skewed-packed storage. For this method of storage, an $m \times n$ matrix is divided into two submatrices designated by the words easy and hard. First p is chosen to be one of {64, 128, 256, 512} depending on the number of quadrants used and the word size. The easy submatrix has dimension $m \times (h \cdot p)$, where $h = [n/p]$*, and the hard submatrix has dimensions $m \times (n - h \cdot p)$.

Each row of the easy submatrix is stored across the PEM's using as many memory rows of p words as necessary. The PE number of the first element in each memory row is determined by considering its matrix row number. For row i, the first element appears in PE_Φ, where $i \sim \Phi (\text{mod } p)$ and $1 < \Phi \leq p$. Succeeding elements extend across the same memory row, then wrap around to fill in any remaining spaces preceding location PE_Φ in the same memory row.

To conserve storage space, rows in the hard part of the matrix are treated as columns and columns as rows; then the hard submatrix is also skewed.

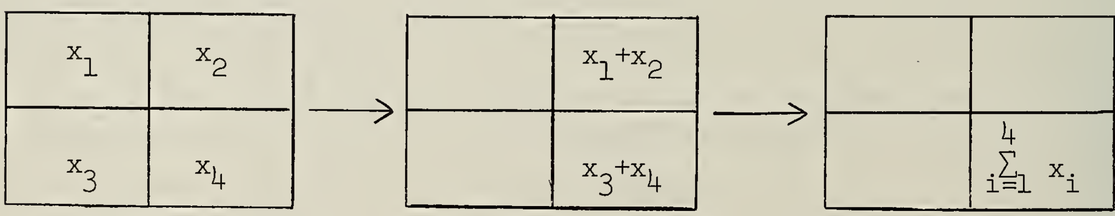
* [x] = greatest integer less than or equal to x.

The amount of wasted space resulting from this scheme is $(n - [n/p])(p - j)$, where $j = m - [m/p] \cdot p$.

The skewing technique allows easy access of the rows or columns of a matrix with proper indexing. The packing allows a high degree of memory use for matrices with n not congruent to p(mod p).

The algorithm for matrix multiplication developed for ILLIAC IV using the skewed-packed storage scheme is highly parallel, involving the formation of p product elements at the same time. If the product of matrix A and matrix B is C, this means that (for any i within the range of the row dimension of C) p elements of row i can be calculated in parallel, except when the hard submatrix of B is under consideration. Such a result is achieved essentially by multiplying each $a_{i,k}$, for the given i, times the k^{th} row of B and adding together the sums, where k ranges over the number of columns of matrix A.

It should be noted that when the hard submatrix is being used to form product elements only ℓ PE's are in use since only ℓ products elements are being formed, where ℓ is the number of columns of the hard submatrix of B. If ℓ less than approximately P/3, for this last portion of the multiplication procedure, a log-sum method where only one product element of C is found at a time can be used to advantage. Such a technique is illustrated graphically by:



Consider A a real matrix of dimension $m \times n$, B a real matrix of dimension $n \times q$, the estimated time needed to form their product, assuming skewed-packed storage, is $11 \times m \times n \times ([q/p] + 1) \times 125$ nanoseconds.

4.3.3.3 Gauss-Jordan Inversion of Matrices

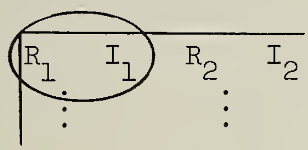
The Gauss-Jordan method for matrix inversion and for solving a system of simultaneous equations involves pivot searching, normalizing, and scaling. In theory, if A is a $n \times n$ nonsingular matrix to be inverted the $n \times 2n$ matrix $[A,I]$ is formed and operated upon. However, in practice only about n^2 memory locations are needed. The skewed-packed storage scheme can be used and it allows row and column interchanges that arise. Timing estimates indicate that a real $n \times n$ matrix can be inverted in approximately $3840\ n^2$ nanoseconds using 256 PE's and 64-bit words. Thus a 700×700 matrix can be inverted in about two seconds.

4.3.3.4 Adaptation to Complex Matrices

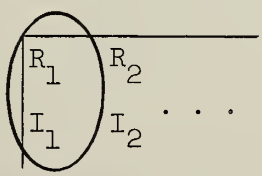
Both matrix multiplication and inversion can be easily adapted to complex matrices.

The proposed storage schemes for complex matrices are the following:

(a) The first scheme allows for the storage of the real and imaginary parts of an element thus:



(b) The second scheme:



Storage is again skewed and packed in both cases; however, neither scheme affords a decided advantage.

4.3.3.5 Multiplication of Sparse Matrices

The problem of sparse matrix multiplication is to find a method which will eliminate the need to store the zero elements of a sparse matrix and which will still allow an efficient multiplication program using the general method of section 4.2. Two methods of storing, the individual-tag method and the bit-word method, are effective in different cases.

For both these methods, storage of the nonzero elements is the same. The zero elements are removed and individual column packing is used as in the following example (1):

$$\begin{vmatrix} a_{11} & 0 & 0 \\ 0 & 0 & a_{23} \\ 0 & 0 & a_{33} \\ a_{41} & 0 & a_{43} \end{vmatrix} \longrightarrow \begin{vmatrix} a_{11} & a_{32} & a_{23} \\ a_{41} & x & a_{33} \\ x & & a_{43} \\ & & x \end{vmatrix}$$

In the individual-tag scheme the actual matrix row number for each nonzero element is stored in the same relative position. For the packed matrix of example (1), the individual tags are:

$$\begin{vmatrix} 1 & 3 & 2 \\ 4 & x & 3 \\ x & & 4 \\ & & x \end{vmatrix}$$

In order to find the actual rows, successive subtractions of row numbers desired are carried out in the following manner:

RGI	0	0	0	index register initialized
RGA	1	3	2	tags
RGA	0	2	1	subtract 1
RGA	a_{11}	0	0	first actual row
RGI	1	0	0	index register increase
	4	3	2	tags
	2	1	0	subtract 2
	0	0	a_{23}	second actual row
	1	0	1	index register increase

Two more iterations in the same manner yield the third and fourth actual rows.

The bit-word scheme stores a word for each actual row of the matrix. This bit word is a sequence of zeros and ones, where zero represents a zero element and one represents a nonzero element in that position of the actual matrix. Again using example (1), the bit words stored are:

1st row	2nd row	3rd row	4th row
100 ,	001 ,	001 ,	101 .

The result in memory is a matrix with dimensions of the actual matrix but requiring less space in memory since each element is only one bit wide.

Both algorithms may be adapted for 64-bit or 32-bit word lengths and for complex sparse matrices.

Comparing the multiplication algorithms for two real and sparse matrices A and B, we have approximately:

$$40 \times m \times \left| q/p \right| \times ((9 + 3n) \times \left| n/p \right| + 4 \times D_A \times n + 7) \text{ nanoseconds}$$

For the individual tag algorithm as opposed to:

$$40 \times m \times \left| q/p \right| \times (14 \times \left| n/p \right| + 4 \times D_A \times n + n + 10) \text{ nanoseconds}$$

for the bit-word algorithm, where D_A is the density of A and, again, $p = 64$, 128, 256, or 512. An inspection of the above formulas indicates that the bit-word is faster for almost all cases, and is preferred when the only consideration is the speed of matrix multiplication. However, the individual tag scheme becomes quite useful for finding a given actual matrix row. When such a search is not being conducted in a systematic row by row fashion, using each row, the scheme would require constant shuffling in and out of CU memory and would be inefficient.

4.4 Application

4.4.1 Introduction

The applications effort is proceeding along roughly the same lines as indicated in earlier quarterly reports. In addition to the efforts discussed below, several small activities have been underway. These include a study of symbolic polynomial manipulation, ordering data throughout all of the ILLIAC IV memory, underground stress-strain model, and eigenvalue calculations.

The applications work has been valuable in discriminating between necessary and unnecessary hardware ideas. It is also influencing the design of user programming languages.

4.4.2 Solution of Problems in Partial Differential Equations

Briefly summarized, we have continued our study of methods for hydrodynamics and of alternating direction implicit techniques and begun the investigation of methods in nuclear reactor calculations.

The two-dimensional hydrodynamics Eulerian program described in the previous quarterly report was completed in both FORTRAN and an early ILLIAC IV assembly language. An immediate modification of the latter was undertaken to permit utilization of the 32-bit floating point mode of operation. At present algorithm is being recoded in a higher level ILLIAC IV language.

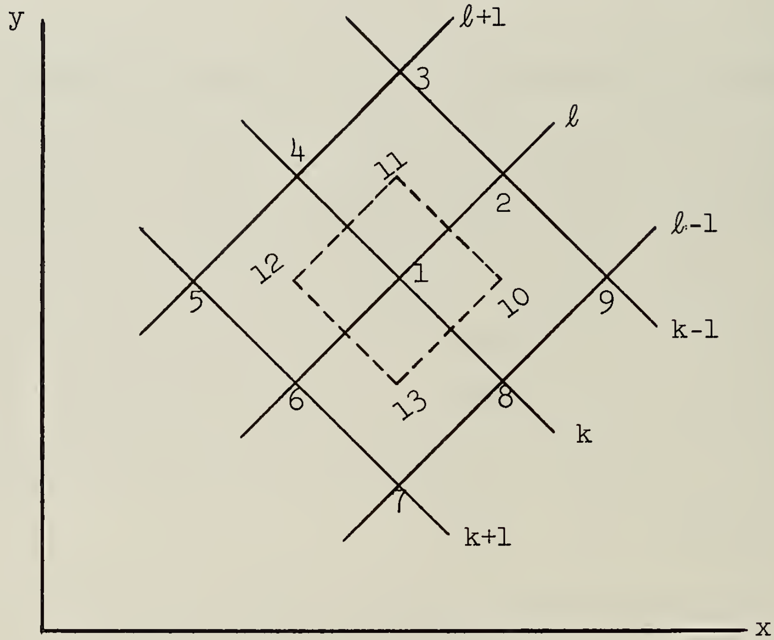
A two-dimensional Lagrangian formulation has been prepared and is being programmed. The Lagrange grid in contrast to the fixed mesh of the Eulerian calculation is thought of as moving with the fluid. Problems involving the motion of thin bands of different fluids over distances much greater than their width are more easily and naturally handled by this procedure. The differential equations in Lagrange coordinates are shown below.

$$\frac{Du}{Dt} = -\frac{1}{\rho}\frac{\partial P}{\partial x} \qquad \frac{Dv}{Dt} = -\frac{1}{\rho}\frac{\partial P}{\partial y}$$

$$\frac{Dx}{Dt} = u \qquad \frac{Dy}{Dt} = v \qquad \rho J = \text{constant}$$

$$\frac{De}{Dt} = \frac{P}{\rho^2}\frac{D\rho}{Dt} \qquad P = P(e,\rho)$$

where J is the Jacobian $\left\{\frac{(x,y)}{(a,b)}\right\}$ and e the internal energy per unit mass.



The following definitions employ the numbering given above:

$$J^n_{k+\frac{1}{2},\ell+\frac{1}{2}} = \frac{1}{2}\left\{(x_3 - x_1)(y_4 - y_2) - (x_4 - x_2)(y_3 - y_1)\right\}^{(n)}$$

let

$$\overline{P} = P + q \qquad \text{(q is an artificial viscosity)}$$

$$\left[\overline{P},x\right]^n_{k,\ell} = \frac{1}{8}\left\{(\overline{P}_{11} - \overline{P}_{13})(x_4 + x_5 + x_6 - x_8 - x_9 - x_2) - (\overline{P}_{12} - \overline{P}_{10})(x_2 + x_3 + x_4 - x_6 - x_7 - x_8)\right\}^{(n)}$$

$$(\rho J)^n_{k,\ell} = \frac{1}{4} \quad (\rho J)^n_{10} + (\rho J)^n_{11} + (\rho J)^n_{12} + (\rho J)^n_{13}$$

$$\left[u_x + vy\right]^{n+\frac{1}{2}}_{k+\frac{1}{2},\ell+\frac{1}{2}} = \frac{1}{J^{n+1}_{k+\frac{1}{2},\ell+\frac{1}{2}}} \left\{ \sum_{i=1}^{3} \left[\frac{(u_{i+1} + u_i)}{2}^{(n+\frac{1}{2})} (y_{i+1} - y_i)^{(n+\frac{1}{2})} - \frac{(v_{i+1} + v_i)}{2}^{(n+\frac{1}{2})} (x_{i+1} - x_i) \right] \right\}$$

With these definitions the Lagrange difference equations are given by:

$$u^{n+\frac{1}{2}}_{k,\ell} = u^{n-\frac{1}{2}}_{k,\ell} - \Delta t \; \frac{[\bar{P},y]^n_{k,\ell}}{(\rho J)^n_{k,\ell}}$$

$$v^{n+\frac{1}{2}}_{k,\ell} = v^{n-\frac{1}{2}}_{k,\ell} + \Delta t \; \frac{[\bar{P},x]^n_{k,\ell}}{(\rho J)^n_{k,\ell}}$$

$$x^{n+1}_{k,\ell} = x^n_{k,\ell} + \Delta t \; u^{n+\frac{1}{2}}_{k,\ell}$$

$$y^{n+1}_{k,\ell} = y^n_{k,\ell} + \Delta t \; v^{n+\frac{1}{2}}_{k,\ell}$$

$$\rho^{n+1}_{k+\frac{1}{2},\rho+\frac{1}{2}} = \rho^n_{k+\frac{1}{2},\ell+\frac{1}{2}} \; \frac{J^n_{k+\frac{1}{2},\ell+\frac{1}{2}}}{J^{n+1}_{k+\frac{1}{2},\ell+\frac{1}{2}}}$$

$$q^{n+\frac{1}{2}}_{k+\frac{1}{2},\ell+\frac{1}{2}} = \frac{1}{2}C^2 \left[(\rho J)^{n+1}_{k+\frac{1}{2},\ell+\frac{1}{2}} + (\rho J)^n_{k+\frac{1}{2},\ell+\frac{1}{2}}\right] \begin{cases} \left[(u_x + v_y)^{n+\frac{1}{2}}_{k+\frac{1}{2},\ell+\frac{1}{2}}\right]^2 \\ 0 \end{cases}$$

if

$$(u_x + v_y)^{n+\frac{1}{2}}_{k+\frac{1}{2},\ell+\frac{1}{2}} < 0$$

if

$$(u_x + v_y)^{n+\frac{1}{2}}_{k+\frac{1}{2},\ell+\frac{1}{2}} \geqslant 0$$

$$e^{n+1}_{k+\frac{1}{2},\ell+\frac{1}{2}} = e^{n}_{k+\frac{1}{2},\ell+\frac{1}{2}} + \bar{P}^{n+\frac{1}{2}}_{k+\frac{1}{2},\ell+\frac{1}{2}} \times \left\{ \frac{(\rho^{n+1} - \rho^{n})_{k+\frac{1}{2},\ell+\frac{1}{2}}}{(\rho^{n+1}\rho^{n})_{k+\frac{1}{2},\ell+\frac{1}{2}}} \right\}$$

$$P^{n+1}_{k+\frac{1}{2},\ell+\frac{1}{2}} = P\left(e^{n+1}_{k+\frac{1}{2},\ell+\frac{1}{2}} \quad P^{n+1}_{k+\frac{1}{2},\ell+\frac{1}{2}} \right)$$

the

$$P^{n+\frac{1}{2}}_{k+\frac{1}{2},\ell+\frac{1}{2}}$$

in the equation for

$$e^{n+1}_{k+\frac{1}{2},\ell+\frac{1}{2}}$$

is obtained by using

$$P^{n}_{k+\frac{1}{2},\ell+\frac{1}{2}}$$

as a first estimate and iterating.

Neighboring Lagrange lines would be assigned to neighboring PE's. Difficulties develop in handling the boundary points and best methods for their solution are being looked at.

In our investigation of Alternating Direction Implicit Techniques, we are considering in some detail the typical case of the solution of the two dimensional heat equation:

$$\frac{\partial u}{\partial t} = \frac{\partial}{\partial x} (k\frac{\partial u}{\partial x}) + \frac{\partial}{\partial y} (k\frac{\partial u}{\partial y})$$

in a rectangular domain. A high level language ILLIAC IV program is being written for this problem. We assume the mesh is rectangular and uniform throughout the region and that there are 256 × m mesh points. With these assumptions, several of the problems we have considered are: (a) How should the mesh be stored for maximum efficiency? (b) How should boundary points be handled? (c) What type of index arithmetric will be needed to change from solution of equations for rows to solutions of equations by columns?

The answers to these questions we have arrived at so far are as follows: (a) The mesh points should be stored as elements of a skewed matrix--in the manner of the ILLIAC IV matrix multiplication scheme. (b) Boundary points may be stored either in the appropriate PE (i.e., where they will be needed) and mode control used to indicate whether or not a boundary point is being worked on, or the boundary values may be broadcast to the appropriate PE when they are needed. (c) The question of indexing is still being studied.

In addition to this program, preliminary investigation has revealed potentially interesting ADI applications for three-dimensional parabolic and elliptic equations[1,2] and for linear hyperbolic systems in two dimensions.[3] The related problem of quasi-tridiagonal matrix inversion is also being studied.[4]

Our study of Reactor Calculations began with the physics of neutron diffusion; such topics as scattering, neutron cross sections, energy, neutron flux, fission, and criticality were considered. The main interest, however, was how these topics applied to the numerical solution of the group diffusion equations.

The time-independent diffusion model is obtained from the Boltzmann equation by assuming that scattering is almost isotropic in the laboratory coordinate system. For each energy group, a partial differential equation for each group is then replaced by suitable finite difference equations. The determination of the criticality constant becomes an eigenvalue problem in which the power method may be used to obtain a solution. By using a nine point star and

considering the neutron balance in an elementary cell instead of a grid point, a higher accuracy for the eigenvalue results.

The point over-relaxation method was mainly considered in solving the linear algebraic system that arises from replacing the differential equations by a set of finite difference equations. (Although line and two-line over-relaxation was seen to be applicable, as well as alternating direction implicit methods using a five point star.)

Basically, the process involves the computation of neutron fluxes for each energy group. This is the inner iteration, where methods of over-relaxation may be used. Then the next approximation to the neutron source function is calculated. An inner iteration together with a source calculation constitutes an outer iteration. As mentioned, the outer iteration involves the power method.

At present we are studying the solution of the transport equation in spherically symmetric geometry for one velocity group by a technique which includes the S_N-method of B. Carlson.

The equation is:

$$\left\{\frac{1}{v}\frac{\partial}{\partial t} + \mu\frac{\partial}{\partial r} + \frac{1-\mu^2}{r}\frac{\partial}{\partial \mu} + \sigma(r)\right\}\Phi(t,r,\mu) = S\left\{\varphi,t,r,\mu\right\}$$

Φ - the particle density

σ - the total cross section for loss of particles

μ - the cosine of the angle between the radius vector and the velocity vector

v - the particle speed

S - is a source term

The method is described by Keller and Wendroff.[5]

4.4.3 Numerical Weather Prediction

At the date of the last progress report, a solution on ILLIAC IV numerical weather prediction model similar to that developed by Kasahara and Washington at NCAR was nearly finished. Since then, timing studies have been performed with the following approximate results:

(a) ILLIAC IV time required to advance all variables at all grid points ten minutes in time = .12 second.*

(b) This represents a 5000:1 speedup over real time and a 600:1 speedup over the execution time of the parent model on NCAR's 6600.

The 600:1 speedup is inaccurate in the sense that the model coded on ILLIAC IV has eight times more grid points than the NCAR model, with roughly the same computational complexity per point as the NCAR model.

A straight-forward method of converting the 64-bit version previously coded to efficient 32-bit operation has also been discovered. Because the grid points have symmetry through the plane of the earth's equator, it is necessary only to make the left half of a 32-bit word the value of a variable at a point in the northern hemisphere and the right half the value of the same variable for the symmetric point in the southern hemisphere. Then efficient use of the 64-bit code simply requires a few modifications in indexing, routing at the equator, and mode control, while most parts of the code remain the same; this should allow a nearly complete 2:1 speedup.

Implicit in the complexities of numerical weather prediction algorithms is the need for a higher level language for ILLIAC IV. Unfortunately the same complexities make implementation extremely difficult. Certainly a large part of computing time will be spent in

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* Figures based on an approximate correspondence between an early version of ILLIAC IV machine language and the machine language presented in the Burroughs Final Technical Report.

arithmetic operations which can easily be written in ALGOL- or FORTRAN-like substitution statements; but the geometric structure of the mesh makes it very difficult to consider the algorithm as a series of matrix or vector operations. This means that the program will have to work on one mesh point (in actuality sixty-four points) and then jump to another point to perform the same calculations. The programmer will thus have to carefully consider various storage schemes for point by point calculation (sixty-four points at a time), while the compiler can only allow him to set up some 1:1 correspondence between his storage allocation and the physical coordinates of the points. Then the program can refer to the physical coordinates rather than storage locations.

The next problem to be considered for ILLIAC IV is that of "irregular" grids. It is desirable from the point of view of stability that the grid points be distributed with uniform density on the earth's surface. The NCAR model represents a rough approximation to uniform density by removing points only in areas where stability begins to be lost. A recent development by Kurihara at the U. S. Department of Commerce General Fluid Dynamics Laboratory comes much closer to uniform distribution. This grid loses four points with each successive line of latitude, i.e., sixty-four points at the equator, sixty points on the first grid line above the equator, fifty-six points, ..., four points on the first grid line below the pole.

Furthermore, Kurihara has developed a thirteen point finite difference scheme based on Green's theorem for the surface of the sphere:

$$\iint_{\Sigma} \nabla \times \vec{V}x = \int_{\delta\Sigma} \vec{V}x \times \vec{n} \quad ,$$

where Σ is a small rectangular region surrounding a grid point and $\delta\Sigma$ is its boundary. This equation means that $\nabla \times \vec{V}x$, the flux divergence of the scalar x summed over the region Σ, must equal the transport of x over the boundary of Σ. Using the mean value theorem for

suitably constructed regions (rectangles) on the sphere, it is possible to develop finite difference approximations for $\nabla \times \vec{V}x$ and hence for $\frac{\delta \mu x}{\delta \lambda}$ and $\frac{\delta \mu x}{\delta \varphi}$ all of which are important in the fluid dynamics equations.

The problem for ILLIAC IV is that the grid system allows no obvious storage allocation.

4.4.4 Linear Programming

4.4.4.1 Introduction

Original objectives and definitions outlined in the previous quarterly report still appear to be valid in view of the evolution of the hardware design.

Mr. D. Tabak has finished his work at the University and is no longer associated with the project. Results of the floating point precision investigation are reported in following paragraphs.

Mrs. J. Tschopp has joined the Linear Programming effort. Initially her assignments will be to code in detail many of the options in program operation, thereby aiding in the determination of the fine structure of the finished systems.

4.4.4.2 LP Coding

Since most of the execution time is spent in the "inner loops" of the algorithm, these received first attention for coding experience and machine evaluation. Evolution of the PE structure necessitated recoding the inner loops to acquire some measure for evaluation.

In one instance the mode registers were reduced to a single enable-bit. However, the most ostensibly drastic change was reduction of four storage registers to one, and three index registers to one. First indications were that operating time would be tripled due to additional storage cycles; however, this was not the case. By Parkinson's Law, since the registers were there, they had been used. Additional thought toward program organization showed the realistic time

sacrifice was only 5 to 10 percent. As it developed, having one register of each type was sufficient for the task, and duplication provided only small speed improvements. However, removal of the registers altogether would cost a many-fold degradation in performance.

Schemes for packing and referencing sparse vectors are being examined extensively. The system efficiency will depend significantly upon this point. Preliminary investigations lead to the following schemes and observations:

(a) Special provision is necessary for long vectors to be continued in an adjacent PE. Implementation of this scheme is fairly straight forward.

(b) A control string with a bit indicating zero or nonzero for each element in the associated vector is one scheme; as above only the nonzero elements are stored. Decoding the control string requires some execution time; however, one variation of this scheme permits elements to reside in the same PE, which would be the case if the entire vector were stored. This may give some computational advantage since the solution and associated vectors (x, π, c, ...) are assumed to be dense, and are located uniformly in the PE s.

(c) An extension of the idea of the hybrid control string proposed for the pipeline machine by Texas Instruments, (involves the organization of the string into bytes,) some indicating gap width (in multiples of eight zeros), and others indicating position (as in b), but within a eighborhood of eight elements. This scheme is advantageous if the vector is locally dense, but sparse on the average. LP problems frequently tend to exhibit this property.

4.4.4.3 Arithmetic and Precision

This investigation was made to examine rounding schemes and various exponent bases within a given word size. The study was made in context of inversion of three twentieth order matrices; coefficients being randomly generated over uniform, logarithmic, and exponential distributions. Some of the results are presented in the following tables. It is felt that the results are fairly typical, but care should be used in drawing too many conclusions from a small sample.

Table I

Simple Truncation Cases

		Error		
Exp. Base	Mantissa Length	Uniform	Exponential	Logarithmic
2	23	$20. \times 10^{-10}$	6.5×10^{-9}	3.1×10^{-10}
4	24-23	6.7	5.1	2.0
8	24-22	47.	16.	4.3
8	25-23	11.	6.4	1.0
16	25-22	8.1	16.	4.9

Table II

Magnitude Rounded Cases

		Error		
Exp. Base	Mantissa Length	Uniform	Exponential	Logarithmic
2	23	1.3×10^{-10}	2.0×10^{-9}	$.67 \times 10^{-10}$
4	24-23	.89	.60	.28
8	24-22	3.9	3.7	1.1
8	25-23	.90	.37	.13
16	25-22	1.8	.88	.89

Table III

M + 1^{th} Bit ORed with M^{th} Bit

		Error		
Exp. Base	Mantissa Length	Uniform	Exponential	Logarithmic
2	23	$12. \times 10^{-10}$	2.1×10^{-9}	1.1×10^{-10}
4	24-23	2.3	1.2	.75
8	24-22	21.	12.	1.4
8	25-23	3.2	3.0	.37
16	25-22	5.6	3.9	2.7

(The range on mantissa length is a result of leading zeros in normalized representation. These particular lengths were chosen so that within a fixed word length expressible magnitudes would be approximately equivalent. The error measurement is the square of the Euclidean norm of $A^{-1} A - I$.)

Magnitude rounding appears to have more significant effect on the error than different exponent base although (4, 24-23) and (8, 25-23) are typically better than (2, 23) cases. The latter is not particularly surprising, but (4, 24-23) seems to be giving something for nothing in that the exponent range is essentially the same as (2, 23), and it provides 24 bits of precision for two-thirds of its representable numbers (approximately one-half of the occurrences). This question is resolved when one considers that in normalized form the highest order mantissa bit in (2, 23) representation is always a one (excepting true zero) and consequently need not be stored. Thus, the hardware could be made to operate in such a way that (2, 24) would be its virtual arithmetic (achieved by not storing the high order bit of the (2, 24) calculation). Considering the additional hardware and programming effort associated with virtual (2, 24), however, the (4, 24-23) system appears very attractive.

Table III exhibits the effect of logical ORing, the highest order truncated bit with the lowest order saved bit. This scheme gives less biased truncation than ignoring the discarded bits altogether. Overall, the ORing scheme appears betters than simple truncation, but less effective than magnitude rounding. Nevertheless, the scheme does have the advantage that it can be accomplished in less time than a full add.

An alternate scheme for unbiased rounding was also evaluated. Results were stored simple truncated, but a one bit was always assumed to be in the position beyond the lowest order bit. Prior to arithmetic operations the one bit was ORed into the $M + 1^{st}$ position, and then the operation proceeded normally. The scheme was essentially as effective as magnitude rounding in reduction of the measured error, however, no time was necessary to perform the rounding addition.

The effects of algebraic rounding were also investigated. This situation may arise when an unknowledgeable programmer algebraically adds the rounding factor without considering the sign of the number being rounded, i.e., positive operands are increased in magnitude, negative numbers are decreased in magnitude. This practice probably should be considered a programming error since the associated error is considerably greater than that of simple truncation.

Finally, it was interesting to notice that the elements of the inverse matrix exhibited a number of fixed positions of accuracy. This effect is illustrated:

ss.ssssii	largest magnitude coefficient of inverse
.00ssiiiiii	least magnitude coefficient of inverse

where digits in positions "s" did not change for different cases and digits in positions "i" varied. Apparently, this is a result of adding numbers of differing exponents. The effect is similar to fixed point

arithmetic with a constant scaling factor. If this is typical of matrix operations, then pre-scaling the input to minimize the range of nonzero element magnitudes tends to improve the significance of the results. It is hoped that the magnitudes of the inverse coefficients will be similarly influenced. (Poorly conditioned matrices remain a problem.) The main advantage of floating point arithmetic may be that it is not necessary to choose apriori an appropriate constant scale factor; but this is gained at a sacrifice of bits for the exponent.

4.4.5 Seismic Array

4.4.5.1 Introduction

The seismic array is not a new concept. Multiple-sensor systems have long been used in seismological research and as an aid in geophysical prospecting. In the last few years, however, largely because of its particular usefulness in monitoring underground nuclear blasts, the seismic array has received renewed attention. It is with the nuclear test detection problem in mind that a study of seismic arrays is being conducted.

The advantage of seismic arrays lies not so much in increased sensitivity but rather in the selectivity obtainable by certain multi-channel processing techniques. Among the techniques in current use[6], those which are classed as "multichannel filtering are the most powerful and also the most challenging from a data processing standpoint. The design and implementation of multichannel filters is the largest phase of the present study.

4.4.5.2 Design Considerations

The design of two particular filters has been considered: the maximum-likelihood filter, developed at Lincoln Laboratory[7] and the least-square filter which was introduced by Texas Instruments[8,9] as an extension of methods due to Wiener and and Levinson[10]. Although

the ML and the LS filters are based on distinct concepts and require slightly different knowledge about signal and noise structure, their design is similar in that they can both be best obtained using a recursive method due to Robinson[11].

4.4.5.2.1 Filter Characteristics

The maximum-likelihood filter has the following characteristics:

(a) If identical signals are applied to each channel, the output is this same signal.

(b) If noise having a predetermined structure is applied to the system, the output variance is minimal.

It is implicit in (a) that the array is steered to monitor a particular geographical region by applying suitable delays to the individual sensor outputs. It should be noted that this type of filter does not depend on a specific structure of the signal, other than its arriving as a plane wavefront.

The least-square filter is characterized by the following:

(a) For signal and noise of a predefined structure, the square of the difference between filter output and signal (at some particular sensor) is minimal.

In contrast to the ML filter the structure of both signal and noise must be known. Also note that this filter accepts signal from all azimuths and dips.

4.4.5.2.2 Time Series Correlation

The design of ML and LS filters depends on knowledge of how noise (and signal in the LS case) is correlated between sensors. Correlation functions may be obtained by Fourier transformation of a theoretical spectral model[8] or by actual convolution of the various time series involved. Both processes can be handled by ILLIAC IV in a highly parallel manner.

4.4.5.2.3 Robinson's Algorithm

Once the necessary correlation functions have been determined, the filter weights for both ML and LS filters are determined by implementing the Robinson Algorithm. Robinson's Algorithm entails a series of matrix operations, all of which have been programmed, and thus will be executed in a highly parallel manner.

4.4.5.3 Filter Implementation

The implementation of a multichannel digital filter involves the convolution of the pre-determined filter weights with the input time series. This is done for each channel and results are summed to produce the filter output. This process is effected by having each sensor feed a particular PE and intermittently summing across the PE array.

4.4.5.4 Real Time Processing Problem

As a test of ILLIAC IV capability, the following real time processing problem is being studied. For convenience we are temporarily considering the data processing requirements of only 20 of the 21 subarrays.

(a) Based on 1000 noise samples for each sensor, calculate all 625 correlation functions corresponding to a single subarray. Each correlation function is to be evaluated for 100 time delays. Do this for each subarray.

(b) Using these correlation functions design, for each subarray, a 25 channel least-square filter. Assume signal correlation functions are available and that requirements dictate a 100-point filter.

(c) Simultaneously, process the sensor outputs using a previously designed filter, and test for events of interest.

Order of magnitude estimates are available for the above problem.

(a) Several seconds;

(b) One-half minute;

(c) Several milliseconds/.1 second cycle time*.

Input/output problems that may arise if it is desired (in a) to base the computation of correlation functions on large (say 10,000) noise samples will be considered shortly.

4.4.5.4.1 Event Detection

Event detection consists of monitoring the 20 filter outputs for sudden increases in energy. A simple criterion for concluding an event has occurred might be that all filters produce an output above a certain threshold within a certain amount of time. More complicated event detection schemes need not be burdensome on computer time.

4.4.5.4.2 Source Location

The time delays encountered in event detection are due to the finite time that it takes for the wavefront to move across the array. As measures of the wavefront arrival time, the time delays are saved and used in the computation of a least square wavefront[12]. The azimuth and dip of the signal are obtained from the wavefront analysis and in turn determine the geographic location of the source from pretabulated data.

4.4.5.4.3 Waveform Analysis

If source location does not provide definitive information as to source mechanism, it is necessary to use other criteria to decide

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* Since (c) is to be done continuously as data are presented to the computer, we are interested in the percentage of time it takes to process it. Data become available to each PE every .1 second and after a millisecond have been processed.

whether or not the event is a nuclear blast. Some of these criteria depend on the examination of the filtered signal. Harmonic analysis has been a traditional method of representing time series, and for this purpose a detailed study was made to substantiate ILLIAC IV's ability to execute the Tukey-Cooley algorithm. Certain details of this study have been reported in a previous report. Let us, at this time, merely note that the Fourier Representation of 4096 (64 bit) data points can be obtained in .6 millisecond.

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APPENDIX

Outline of Project Organization

The ILLIAC IV Project is organized on a technical working group basis. It is planned that this organization structure will evolve so as to reflect the degrees of technical specialization required. All of the groups listed below report to the Principal Investigator, Professor D. L. Slotnick.

A. Logic and System Design

R. M. Brown, Professor of Physics
M. Kato, Visiting Professor of Computer Science
R. E. Marks, Research Engineer
G. D. Wood, Research Engineer
- W. L. Heimerdinger, Electrical Engineering
- N. Machado, Electrical Engineering
- J. P. Mandel, Electrical Engineering
- A. Ong, Electrical Engineering
- J. R. Slager, Electrical Engineering

B. Software Development

D. J. Kuck, Assistant Professor of Computer Science
L. E. Anderson, Research Programmer
- C. Barnett, Mathematics
- J. Cook, Physics
- D. Grothe, Mathematics
- A. Halpern, Electrical Engineering
- R. Kusper, Physics
- Y. Muroaka, Electrical Engineering
- B. Okawa, Physics
- R. Wilhelmson, Mathematics

C. Linear Programming

J. P. Blondeau, Research Programmer
- F. Chen, Electrical Engineering
- J. Tschopp, Mathematics

D. Partial Differential Equations Studies

P. J. Wallack, Research Programmer
V. Benokraitis, Mathematics
R. El-Assar, Mechanical Engineering
L. Rudsinski, Mathematics
A. Sameh, Civil Engineering
J. M. Madden, Research Programmer (Weather Applications)

E. Signal Processing

G. M. Ackins, Physics
W. J. Barlow, Mathematics

5. NUMERICAL METHODS, COMPUTER ARITHMETIC AND ARTIFICIAL LANGUAGES

(Supported in part by the National Science Foundation under Grant No. NSF-GP-4646.)

5.1 Numerical Analysis

A new Sequential Extrapolated Implicit method (SEI) was investigated for the solution of linear systems approximating partial differential equations. This technique, like SOR, can be regarded as an accelerated Gauss-Seidel iteration. Acceleration is obtained by performing a shift of origin on the Gauss-Seidel averaging operator. For a point operator, this can be shown to be equivalent to extrapolation, but for a block operator, it is not equivalent. If we consider, for example, a block method for Laplace's equation on a rectangular domain, then the eigensystem of the block matrix provides a spectral decomposition of the problem. In this case, we can examine separately the rate at which the error in the initial approximation to the solution is attenuated in those coordinate directions corresponding to each of the eigenvalues of the block matrix. If the rate of attenuation is plotted against a particular eigenvalue of the block matrix, the resulting curve for SEI lies everywhere below the corresponding curve for SOR except for the largest eigenvalue of the block matrix, where the curves for SEI and SOR coincide. Moreover, the rate for SEI becomes infinite as the eigenvalue of the block matrix decreases from its maximum value to zero, whereas the rate for SOR remains constant.

Also, it is possible to use two acceleration parameters, both extrapolation and shift of origin. Numerical experiments indicate that the resulting iteration is superior to SOR, although formulas for the optimum pair of parameters and for the spectral radius of the resulting iteration matrix have not yet been obtained.

Another device which can be used is a sequence of different origin shifts, one for each block of the array, to annihilate the error corresponding to the largest eigenvalue of the block matrix. Also, we can combine variable origin shifts with variable extrapolation to annihilate the error corresponding to a smaller eigenvalue also. For test problems, both of these techniques produce rates of convergence higher than for SOR, the latter one by approximately 50 per cent.

(D. B. Gillies and L. K. McDowell)

5.2 Equivalence of Context-Free Grammars

Two context-free grammars are said to be weakly equivalent if the languages (i.e., the sets of strings) which they generate are equal. From the point of view of processing a formal language, as required in almost all computer applications (e.g., compilation), the structure of a sentence with respect to a grammar is of great importance. Weak equivalence, a concept which considers strings of characters without regard to their syntactic structure, hence misses most aspects of interest in the processing of formal languages.

Various notions of strong equivalence have been advanced to remedy this situation, often, however, without having been adequately defined. We propose a concept of equivalence of context-free grammars, called structural equivalence, which is more restrictive than current concepts of strong equivalence but takes into account all the structural features of the two grammars. Two context-free grammars, G_1, G_2, are said to be structurally equivalent iff there is a finite state machine M that maps the set of all completed derivations with respect to G_1 one to one onto the set of all completed derivations with respect to G_2 such that the terminal line of each completed derivation in G_1 and the terminal line of its image in G_2 are identical. This means that, given G_1, G_2, M as described above, and a string $x \epsilon L(G_1)$ together with its derivation in G_1, one can construct a derivation of x in G_2 by scanning the derivation in G_1 from top to bottom.

Ambiguities are preserved by structural equivalence. Various well-known "normal forms" of context-free grammars preserve structural equivalence. We hope to show that the question whether or not two context-free grammars are structurally equivalent is decidable, a result which would stress the difference to other concepts of equivalence and enhance the practical applicability of our concept.

(J. Nievergelt and S. Seth)

5.3 Autonomous Arithmetic Unit Structures

The analysis of base two signed digit division was continued. A lower bound was found for the number of digits of the partial remainder and of the divisor upon which the quotient digit sequence depends. The lower bound was determined for quotients in minimally redundant form and maximally redundant form.

If

k = number of quotient digits obtained per comparison (i.e., 2^k is the effective radix of division)

$k \geq 2$

q_{ij} = the i^{th} quotient digit determined during the j^{th} comparison ($q_{ij} \in \{-1,0,1\}$)

Then

$$Q_j = \sum_{i=0}^{k-1} q_{ij} 2^i = j^{th} \text{ 'quotient value'}.$$

Then if $|Q_j| \leq 2^{k-1}$ for all; the minimum redundancy case, the quotient value is functionally dependent on the 2k+3 most significant digits (base 2) of the partial remainder and the 2k+2 of the divisor.

And if $|Q_j| \leq 2^k - 1$ for all; the maximum redundancy case, the quotient value is functionally dependent on the k+3 most significant digits of both the partial remainder and the divisor.

The latter is much more desirable from the standpoint of quotient digit formation. However, unlike the former case, in which it can be stated that at least $\frac{k-1}{2}$ of the digits determined during each comparison can be zeros, the only lower bound in the latter case for the number of zeros is zero. If, however, k+1 (i.e., $Q_j = \sum_{i=0}^{k} q_{ij} 2^i$) rather than k digits are allowed to represent quotient values, one can then make a statement that at least k/2 of the quotient digits determined during each comparison can be zeros. If $q_{kj} = 0$, it is ignored. If it is nonzero, an addition or subtraction, as appropriate, but no shift is performed as an extra step. This extra step does not appear to be required too often as it appears necessary to set $q_{kj} \neq 0$ only if $|Q_j| \geq \frac{5}{6} \cdot 2^k$.

(M. J. Pisterzi)

5.4 Theory of Arithmetic Unit Structure

A new approach to the design of digital adders utilizing redundant representation has been found. Such adders have the property that propagation of carries may be limited to a small and fixed number of stages. In practice this number would generally be two or three.

The approach is equally applicable to arithmetic recodings and lends itself to a development of a theory of arithmetic recodings and adder/subtracters utilizing redundancy. The theory makes it possible to find those adders which are optimum in some sense (such as simplicity, shift average, etc.) for a given radix and redundancies of the operands.

The theory appears to be fairly inclusive in that specific adders discovered by others in the past are included in the designs derivable from the theory. The approach has made it clear that addition/ subtraction is a subclass of arithmetic recodings.

(F. Rohatsch)

5.5 Algebraic Manipulation

In recent years considerable effort has been directed toward the implementation of programming systems to perform algebraic manipulations by computer. The objectives have been for the most part the attainment of a system powerful enough to perform at least some of the tedious error-prone intermediate steps in the manipulation of formulas. Various manipulators described in the literature have demonstrated the feasibility of such programs, particularly when required to perform only a few types of operations. At the same time the gross differences in the approaches used to implement the manipulators indicates that much study is still needed to choose the optimum approach given a specific computer configuration and, should the use of these manipulators overtake a conventional computer, to be able to describe an adequate computer design directed specifically toward the implementation of an algebraic manipulator.

One specific area which is being investigated is the study of the use of redundancy in the optimization of operations on general polynomials. The motivations in limiting the investigation to polynomial operations stem

from the fact that addition, multiplication and division are the key operations in any algebraic manipulation and consequently their optimization represents the most important factor in the reduction of computer time and memory required. Also, in most interesting cases both addition and multiplication are commutative and associative, properties which are not fully exploited in current algebraic manipulators. It is anticipated that the use of redundancy in the representation of the polynomials will lead to algorithms in which these properties are made as automatic as possible, and thereby, result in more efficient polynomial manipulations.

If $x_1, x_2, \ldots, x_n$ are indeterminates, we will consider operations on expressions of the form

$$E = \sum_{i=0}^{r} c_i \, x_i^{e_{i1}} \, x_2^{e_{i2}} \ldots x_n^{e_{in}}$$

where

e_{ij} is zero or a positive integer

c_i is an element of the ring over which the polynomial is defined.

In general c_i can be an element of any ring with appropriate restrictions on operations allowed on the polynomials and a corresponding implementation of operations in the ring. Since commutativity will be stressed in the techniques used for manipulations, fields and in particular real numbers will play a correspondingly more important role.

One of the problems to be studied is the method of representing a polynomial in the computer as viewed in relation to the amount of memory required and the relative efficiency of the algorithms forced by a specific representation. The above canonical form of the polynomial will emerge as the desirable representation in most cases but forcing this representation after every operation can also lead to inefficiencies. The terms, indeterminates, exponents and constants comprising the polynomial along with the redundancy information can be connected in a list structure or in a more inflexible format-controlled representation in which the position as well as the specific bit pattern contains information about the polynomial. Here again a study of the trade-off between the two extremes is needed to determine a compromise which will result in efficient use of memory and time under a given computer technology.

The above description gives an overview of the investigation in progress. During the past quarter efforts have been mostly directed toward the implementation of a list processor which will be used to test algorithms and hopefully to gain more insight into the problems of implementing an algebraic manipulator. An assembler which generates compact strings of characters in an intermediate language and an interpreter which processes these strings are functioning satisfactorily but the filing system which saves and loads the the strings comprising a routine is still in the programming stage.

(S. J. Nuspl)

5.6 Artificial Languages

Several methods of EOL language implementation were analyzed. An idea for writing the EOL Interpreter was elaborated. It consists of two basic steps.

1. Writing the Interpreter in abstract form, applicable to a broad class of computers.
2. Adapting this Interpreter to the particular computer belonging to the above class.

An "Outline of EOL Language" was distributed in December, 1966, to senior staff of the department.

(L. Lukaszewicz)

6. ILLIAC II SERVICE USE

(This work is supported in part by Contract No. AT (11-1) 1469 of the Atomic Energy Commission and in part by the University of Illinois.)

6.1 ILLIAC II Program Development

The following changes were incorporated into the operating system tapes on the dates indicated:

A. 9/26/66 MACRO change to

1. Put outside name on a MACRO
2. Insure correct MACRO expansion even if a MACRO is defined within a MACRO and the inside one is defined after the outside one.
3. Correct minor listing problems.

B. 9/27/66

1. New Load Monitor was added which eliminated one manual switch setting in going from MSR→PDP systems by using a special register which could be programmed.

C. 10/11/66 Load Monitor change

1. This involved changing the "load monitor" so that no operator intervention is involved in going from the MSR to PDP-7 tapes. No longer will the operators need to change bits on the PDP-7 in order to start up the system.

D. 10/18/66 MACRO change which allows

1. MACRO to recognize $ control cards (in case one forgets the NICAP 'GO').
2. Also inserts the 'GO' if it has been omitted and tells the user that it has been inserted.

J. Aaron

CalComp Programs

Work continues on the batch processor to add features which will put the user ID number and other relevant information at the head of a user plot. The number of inches of output will also be printed on the operator console.

A subroutine has been written (but not yet written up) which accepts input on cards and constructs calls directly to named subroutines in the CalComp package. This can be used to cause straightforward drawings to be output on the CalComp without the necessity of writing a program.

R. Lyon

6.2 Library Programming

6.2.1 ILLIAC II Library Development

During this period the following subroutines were incorporated in the library:

D1-UOI-GQU3-72-FR

IDENTIFICATION--Legendre-Gauss Quadrature for FORTRAN.

PURPOSE--This is a FORTRAN subroutine to evaluate the integral:

$$\int_a^b f(x)\,dx$$

D1-UOI-GQU4-73-FR

IDENTIFICATION--Hermite-Gauss Quadrature for FORTRAN.

PURPOSE--This is a FORTRAN subroutine to evaluate the integral:

$$\int_{-\infty}^{+\infty} e^{-x^2} f(x)\,dx$$

D1-UOI-GQU5-74-FR

IDENTIFICATION--Laguerre-Gauss Quadrature for FORTRAN.

PURPOSE--This is a FORTRAN subroutine to evaluate the integral:

$$\int_{-\infty}^{+\infty} e^{-x} f(x)\,dx$$

D1-UOI-GQU6-75-FR

IDENTIFICATION--Two-Dimensional Quadrature for FORTRAN.

PURPOSE--This is a FORTRAN subroutine to evaluate the integral:

$$\int_D\int f(x,y)\,dx\,dy$$

D1-UOI-GQU8-76-FR

IDENTIFICATION--Gauss-Jacobi Quadrature for FORTRAN.

PURPOSE--This is a FORTRAN subroutine to evaluate the integral:

$$\int_{-1}^{1} (1+x)^{\beta} f(x)dx \;;\; \beta = 1, 2, 3, 4$$

D1-UOI-GQU7-77-FR

IDENTIFICATION--Gauss-Jacobi Quadrature for FORTRAN.

PURPOSE--This is a FORTRAN subroutine to evaluate the integral:

$$\int_{-1}^{1} (1-x^2)^{\alpha} f(x)\,dx \;;\; \alpha = -\tfrac{1}{2}, \tfrac{1}{2}, 1, \tfrac{3}{2}$$

D1-UOI-GQU9-78-FR

IDENTIFICATION--Gaussian Quadrature for FORTRAN.

PURPOSE--This is a FORTRAN subroutine to evaluate the integral:

$$\int_{-1}^{1} |x|^{\alpha} f(x)\,dx \;;\; \alpha = 1, 2, 3, 4$$

D1-UOI-GQU10-79-FR

IDENTIFICATION--Gaussian Quadrature for FORTRAN.

PURPOSE--This is a FORTRAN subroutine to evaluate the integral:

$$\int_0^1 \ln\left(\frac{1}{x}\right) f(x)\, dx$$

D1-UOI-GQU11-80-FR

IDENTIFICATION--Gaussian Quadrature for FORTRAN.

PURPOSE--This is a FORTRAN subroutine to evaluate the integral:

$$\int_{-\infty}^{\infty} |x|^{\alpha} e^{-x^2} f(x)\, dx \;;\; \alpha = 1, 2, 3$$

D1-UOI-GQU12-81-FR

IDENTIFICATION--Gaussian Quadrature for FORTRAN.

PURPOSE--This is a FORTRAN subroutine to evaluate the integral:

$$\int_{-\infty}^{\infty} |x|^{\alpha} e^{-|x|} f(x)\, dx \;;\; \alpha = 1, 2, 3$$

F1-UOI-MTRXAL-82-NI

IDENTIFICATION--Matrix Algebra.

PURPOSE--A complete program which accepts data cards containing FORTRAN-like statements with operands which are matrices.

B3-UOI-DPELFN-83-NI

IDENTIFICATION--Double Precision Elementary Functions for NICAP.

PURPOSE--Given a double precision argument X, DPELFN calculates sin X, cos X, tan X, e^X, sinh X, cosh X, or tanh X to double precision accuracy; the desired function is indicated by a parameter.

B3-UOI-DPEXHY-84-NI

IDENTIFICATION--Double Precision Exponential and Hyperbolic Functions for NICAP.

PURPOSE--Given a double precision argument X, DPEXHY calculates e^X, sinh X, cosh X, or tanh X to double precision accuracy; the desired function is indicated by a parameter.

B1-UOI-DPTRIG-85-NI

IDENTIFICATION--Double Precision Trigonometric Functions for NICAP.

PURPOSE--Given a double precision argument X, DPTRIG, calculates sin X, cos X, or tan X to double precision accuracy; the desired function is indicated by a parameter.

B3-UOI-CONFRC-86-NI

IDENTIFICATION--Continued Fractions for Double Precision Elementary Functions for NICAP.

PURPOSE--Given a double precision argument x such that $0 < x < \pi/4$, CONFRC calculates sin x, cos x, tan x, e^x, sinh x, cosh x, or tanh x to double precision accuracy; the desired function is indicated by a parameter.

F2-UOI-QRAL-88-FR

IDENTIFICATION--A complete FORTRAN program to find the eigenvalues of an NxN matrix with real elements, using the QR algorithm.

PURPOSE--Given a real NxN matrix A, this program computes N complex numbers $\lambda_1, \lambda_2, \ldots, \lambda_N$ such that $AX_i = \lambda_i X_i$ if X_i is an eigenvector associated with λ_i. The condition number (see METHOD) of each eigenvalue and the number of iterations to compute it are also printed. Also printed are the trace and norm of the matrix, the sum of the eigenvalues and the average number of iterations.

F2-UOI-EVINIT-89-FR

IDENTIFICATION--Eigenvectors of a Symmetric Tri-diagonal Matrix by Inverse Iteration for FORTRAN.

PURPOSE--Given a symmetric tri-diagonal matrix of order n and m eigenvalues for this matrix, EVINIT will calculate the eigenvectors corresponding to the given eigenvalues.

F2-UOI-TSTMTR-96-FR

IDENTIFICATION--Test Matrices for FORTRAN.

PURPOSE--Given the elements of a diagonal matrix, TSTMTR will generate a full matrix similar to the given diagonal matrix and gives the eigenvalues, eigenvectors, and determinant of this matrix. This program can also be used to find the inverse of a matrix (see METHOD).

F2-UOI-HOUSE-97-FR

IDENTIFICATION--Householder's method for symmetric matrices, a FORTRAN subroutine.

PURPOSE--Reduces a symmetric matrix to tridiagonal form.

F2-UOI-CEST1-100-FR

IDENTIFICATION--CEST1 for FORTRAN.

PURPOSE--CEST1 finds the eigenvalues of a symmetric, tri-diagonal matrix by the method of bisection.

Corrections were made to the following subroutines:

M2-UOI-PRINT-17-NI

J5-UOI-CCP5AX-105-FR

J5-UOI-CCP3NR-37-NI

The addition of the family of Gauss Quadrature subroutines GQU3 through GQU12 caused the obsolescence of a number of other subroutines which were deleted. Those subroutines which were deleted are: D1-UOI-GQU2-68-NI along with a number of subroutines called by it.

L. D. Fosdick, Project Director
S. Chase
M. Coane
R. Fleck
B. Richardson
R. Bow

6.3 Engineering Development

6.3.1 Hardware Development

A. An integrated D.C. marginal tester was completely installed in the C.P.U. of ILLIAC II so that all power supply voltages can be controlled from bay 12R.

B. The decoder A chassis address register cable terminations were changed in Core 1.

C. A switch by program was installed in the digital-analog, analog-digital conversion units so as to make it possible for the user to choose the frequency of conversion to be either (10, 20, 30, 40) kilocycles.

D. A modification of indicator cards was made on 12F of the C.P.U.

S. P. Krabbe, L. L. Byers, R. L. Miller

6.3.2 Preventative Maintenance

A. All decoder chasses have been checked out.

B. All air filters in the PDP-7 and 630 were serviced.

C. All spare modules for Core 0 were completely checked out.

D. A D.C. margin was done on C.P.U., DRUM, and Core 1.

E. An AC and DC timing test was run on the C.P.U.

F. The Satellite Processor Unit channel was debugged so as to run Variable Length Transfers.

G. A weekly D.C. margin is being run on the C.P.U. +6.8, -5, -50 at $\geq \pm$ 10%; +25 at +8%, -10%.

H. The disk surfaces on the 1301A I.B.M. disk file were cleaned.

I. A hammer test and sensitive card replacement was done on S.P.U., tape channel 4 and 5, and 1301 channel.

J. A timing margin and adjustment was done on space strobe of Core 1.

K. The new overflow (OV) test showed up a hardware malfunction. It was repaired.

L. Zener diodes (9.1V and 14.5V) in A.S. (13-15)F were checked at min. current levels. All were OK.

S. P. Krabbe, L. L. Byers, R. L. Miller

6.3.3 Engineering Test Programming

A. A previously developed test system (cavities) was used to build up a tape of 12 engineering tests with output on the Teletype.

L. L. Byers

B. The Automatic Engineering System (AES) was recorded on the disk file in that group reserved for maint. tests.

G. Huszar

C. A new version of test for overflow (OV) was completed.

L. L. Byers

D. A block checker test was written and checked-out.

L. L. Byers

6.4 Engineering Maintenance

6.4.1 ILLIAC II Engineering Log Summary - October, November, December, 1966

Error Analysis - ILLIAC II	October	November	December	Totals
Advanced Control	1	1	1	3
Console	1		1	2
Core 0	3		3	6
Core 1	1	1	2	4
DA-AD Converter	4			4
Disk Channel			3	3
Drum			1	1
Drum Channel			1	1
Flow Gating	1	2		3
Interplay	1			1
Power Supplies	1	3		4
PDP-7		2		2
S.P.U. Channel	4	3	3	10
Tape Channel (4)			3	3
Tape Units	5	3	5	13
1301 Disk	1	2		3
1401	6	2	1	9
1402		1		1
1403	2	2	1	5
	31	22	25	78

6.5 Log Summaries

6.5.1 ILLIAC II Use

6.5.1.1 Summary of Use

October, 1966

Scheduled Engineering			58:00
Unscheduled Engineering			28:14
Engineering Development			91:34
Time-Sharing Development and Operation			233:28
Power Off			248:00
Idle			1:52
Miscellaneous (operating, tape rewind, tape skip, tape mounting, reruns of failures, starts of time sharing)			35:36
Total Use			
Training and Education		5:33	
Demonstrations		1:35	
System Update		10:23	
System Development		5:55	
Engineering Maintenance		:03	
Customer Use			
In Systems	23:07		
Short Shots	:40		
Customer Use		23:47	
Total Use			47:16
Total Time			744:00

<u>November, 1966</u>

Scheduled Engineering			54:55
Unscheduled Engineering			16:15
Engineering Development			46:26
Time-Sharing Development and Operation			218:32
Power Off			288:00
Idle			1:30
Miscellaneous (operating, tape rewind, tape skipping, tape mounting, rerun of failures, starts of time-sharing)			20:41
Total Use			
Training and Education		9:26	
Demonstrations		6:20	
System Update		3:35	
System Development		13:27	
Engineering Maintenance		5:30	
Customer Use			
In Systems	34:44		
Short Shots	:39		
Customer Use		35:23	
Total Use			73:41
Total Time			720:00

December, 1966

Scheduled Engineering	57:00
Unscheduled Engineering	46:40
Engineering Development	33:44
Time-Sharing Development and Operation	210:58
Power Off	312:00
Idle	6:36
Miscellaneous (operating, tape rewind, tape skipping, tape mounting, rerun of failures, starts of time sharing)	18:20

Total Use

Training and Education		7:33	
Demonstrations		2:25	
System Update		5:32	
System Development		11:34	
Engineering Maintenance		3:49	
Customer Use			
In Systems	27:36		
Short Shots	:13		
Customer Use		27:49	
Total Use			58:42
Total Time			744:00

6.5.1.2 Summary of Machine Errors

October

Main Frame		3
Core		4
Channels		8
Special Registers		4
Interplay		1
Power Supplies		1
	Total	21

November

Main Frame		3
Core		1
Channels		10
Power Supplies		3
	Total	17

December

Main Frame		1
Core		5
Channels		10
Console		1
Drum		1
Tape Units		5
	Total	23

6.5.1.3 Departmental Running Time

October, 1966

	Number of Runs			Number of Specs			ILLIAC II Usage in Hours		
Dept.	T and Ed	Res	Total	T and Ed	Res	Total	T and Ed	Res	Total
ADV	0	4	4	0	1	1		.007	.007
AAE	258	175	433	9	6	15	2.466	3.794	6.260
AGRON	3	0	3	1	0	1	.010		.010
CE	7	16	23	1	1	2	.015	.453	.468
CHE	0	27	27	0	2	2		.343	.343
DCS	317	467	784	3	4	7	1.177	8.003	9.180
EE	226	145	371	8	7	15	1.196	3.237	4.433
ENGH	2	0	2	1	0	1	.006		.006
MATH	93	0	93	1	0	1	.284		.284
ME	160	8	168	8	2	10	.377	.078	.455
MUSIC	0	11	11	0	1	1		2.225	2.225
NUCE	12	34	46	1	2	3	.018	.231	.249
PHYCS	0	51	51	0	4	4		3.382	3.382
PHYX	0	100	100	0	5	5		.792	.792
TAM	0	54	54	0	4	4		.565	.565
XSSS	0	169	169	0	1	1		.665	.665
STOT-1	1078	1261	2339	33	40	73	5.549	23.775	29.324
DCSSYS	0	724	724	0	10	10		7.793	7.793
TOTALS	1078	1985	3053	33	50	83	5.549	27.568	33.117

T and Ed = Training and Education

Res = Research

November, 1966

Dept.	Number of Runs			Number of Specs			ILLIAC II Usage in Hours		
	Tr and Ed	Res	Total	Tr and Ed	Res	Total	Tr and Ed	Res	Total
AAE	383	170	553	8	5	13	5.652	3.849	9.501
CE	0	6	6	1	0	1		.377	.377
CHE	39	35	74	1	2	3	.130	.768	.898
DCS	227	417	644	4	5	9	.604	18.478	19.082
EE	250	210	460	10	5	15	1.197	1.508	2.705
ENGH	55	0	55	1	0	1	.181		.181
GENE	0	8	8	0	1	1		.014	.014
MATH	17	0	17	1	0	1	.039		.039
MATRL		36	36		1	1		1.368	1.368
ME	157	7	164	5	2	7	.651	.140	.791
MUSIC		1	1		1	1		.005	.005
NUCE		9	9		2	2		.046	.046
PHYCS	41	56	97	2	4	6	.938	4.135	5.073
PHYX		135	135		3	3		2.591	2.591
PSYCH		19	19		1	1		.102	.102
SOC		7	7		1	1		.053	.053
TAM	9	107	116	2	8	10	.041	1.300	1.341
XSSS		86	86		1	1		.642	.642
SUB TOTAL	1179	1309	1488	36	42	78	9.434	35.376	44.810
DCSSYS		955	955		10	10		18.957	18.957
TOTAL	1179	2264	3443	36	52	88	9.434	54.333	63.767

T and Ed = Training and Education

Res = Research

December, 1966

Dept.	Number of Runs			Number of Specs			ILLIAC II Usage in Hours		
	Tr and Ed	Res	Total	Tr and Ed	Res	Total	Tr and Ed	Res	Total
AHE	144	164	308	6	4	10	2.832	1.956	4.788
CE	0	13	13	0	2	2	0.000	1.549	1.549
CHE	74	6	80	1	1	2	.597	.367	.964
CRC	0	1	1	0	1	1	0.000	.001	.001
DCS	129	327	456	4	6	10	2.169	17.767	19.936
EE	161	49	219	9	5	14	.730	.260	.990
ENGH	47	0	47	1	0	1	.278	0.000	.278
IE	2	0	2	1	0	1	.010	0.000	.010
MATH	75	0	75	1	0	1	.161	0.000	.161
MATRL	0	61	61	0	4	4	0.000	.203	.203
ME	106	0	106	6	0	6	.481	0.000	.481
NUCE	0	1	1	0	1	1	0.000	.002	.002
PHYCS	25	43	68	1	2	3	.250	4.138	4.388
PHYX	0	17	17	0	1	1	0.000	.096	.096
PSYCH	0	7	7	0	1	1	0.000	.166	.166
SOC	0	8	8	0	1	1	0.000	.032	.032
THM	8	81	89	2	7	9	.045	1.068	1.113
XSS	0	41	41	0	1	1	0.000	.210	.210
SUB TOTAL (1)	771	819	1590	32	37	69	7.553	27.815	35.368
DCSSYS	0	607	607	0	8	8	0.000	19.889	19.889
TOTALS	771	1426	2197	32	45	77	7.553	47.704	55.257

T and Ed = Training and Education

Res = Research

6.5.2 IBM 1401, 1402, 1403 Use

6.5.2.1 Summary of Use

October, 1966

Scheduled Engineering		1:45
Unscheduled Engineering		21:30
Maintenance		7:03
Tape Test		:05
ILLIAC Preparation		200:33
Other (listing, autocoder, reproduce, cobol, operator training, load, SPS, etc.)		56:37
Power Off		248:00
Idle		208:27
	Total	744:00

November, 1966

Scheduled Engineering		7:45
Unscheduled Engineering		8:35
Maintenance		9:50
ILLIAC Preparation		204:49
Other (listing, autocoder, reproduce, cobol, operator training, load, SPS, demonstrations, etc.)		52:47
Power Off		288:00
Idle		148:14
	Total	720:00

December, 1966

Scheduled Engineering		1:00
Unscheduled Engineering		7:25
Maintenance		3:35
Tape Test		:45
ILLIAC Preparation		140:19
Other (listing, autocoder, reproduce, cobol, operator training, load, SPS, etc.)		44:06
Power Off		312:00
Idle		234:50
	Total	744:00

6.5.2.2 Summary of Machine Errors

October, 1966

1401 Main Frame		6
1403 Printer		2
Tape Drives		2
	Total	10

November, 1966

1401 Main Frame		2
1402 Reader-Punch		1
1403 Printer		2
	Total	5

December, 1966

1401 Main Frame		1
1403 Printer		1
	Total	2

7. IBM 7094/1401 SERVICE, USE, AND PROGRAM DEVELOPMENT

(Supported in part by the National Science Foundation under Grant No. NSF-GP-700).

7.1 New Routines

N1-UØI-INT1-100-SR

7094 interpretive routine. This routine is offered principally as an aid in difficult debugging problems. It offers the capability of checking each instruction in a program before executing it. It also offers the option of printing (off-line) each instruction and the machine registers before executing the instruction.

Programmed by John Ehrman
George Friedman

October 13, 1966

B1-UØI-TAN-109-SR

Single precision floating point tangent and cotangent. For a given floating point number X, this program calculates tangent (X) or cotangent (X). This program is adapted from the University of Chicago tangent and cotangent routines.

Adapted by T. Wang

October 26, 1966

L1-UØI-GTLD3-131-SR

Loader-calling program. This routine calls the system loader during execution time. It will load and execute a program, generated either before or during execution time, from an indicated input tape and disk library. The user's library must be written by the system library writer prior to the usage of GTLD3.

Programmed by Freda Fischer

October 26, 1966

7.2 Log Summaries

Table I - IBM 1401-I

Summary of Use

October, 1966

Scheduled Engineering	2:35
Unscheduled Engineering	4:34
Maintenance	13:59
7094 Preparation	461:59
List/Reproduce	18:23
Code Check	9:05
Tape Dump	5:31
SMP	12:52
Idle	50:03
Total	579:01

Table II - IBM 1401-I

Summary of Machine Errors

October, 1966

1402 Card Reader Punch	6
1403 Printer	1
Total	7

Table I - IBM 1401-II

Summary of Use

October, 1966

Scheduled Engineering		2:05
Unscheduled Engineering		1:15
Maintenance		14:22
7094 Preparation		502:41
List/Reproduce		14:57
Code Check		5:47
Tape Dump		5:19
SMP		5:59
Idle		44:05
	Total	600:30

Table II - IBM 1401-II

Summary of Machine Errors

October, 1966

1402 Card Reader Punch		1
729V Tape Drives		2
	Total	3

Table I - IBM 1401-IV

Summary of Use

October, 1966

7094 Preparation		1:15
Code Check Illiac		8:30
	Total	9:45

Table I - IBM 7094

Summary of Use

October, 1966

Scheduled Engineering				30:42
Unscheduled Engineering				12:44
Maintenance				20:40
Tape Test				1:03
Air Conditioning				:17
Idle				52:33
Miscellaneous (Operator training, tape rewind, system tape mounting, rerun of failing problems, tape shipping, destruction of clock readings)				119:47
Total Use				
Training and Education			38:53	
University Administrative Overhead Use			5:27	
System Modification and Improvement			20:56	
System Updating			1:21	
Customer Use				
In System		307:40		
Relinquish				
AGEC	1:36			
EE	:03			
PHYX	18:31			
Relinquish Total		20:10		
Special Short Shots		1:12		
Customer Use Total			329:02	
			Total Use	395:39
			Total Time On	633:25

Table II - IBM 7094

Summary of Machine Errors

October, 1966

721 Card Punch	1
729 Tape Unit	3
1301 Disk	3
Air Conditioner	2
Total	9

7094 Table III October 1966

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
AAE	327	126	453	7	4	11	2 59.6	2 14.6	5 14.3
ADV	0	23	23	0	1	1	0.0	21.7	21.7
AGE	6	122	128	2	8	10	10.9	1 27.1	1 38.0
AGEC	0	154	154	0	11	11	0.0	4 51.4	4 51.4
AGRON	396	155	551	1	13	14	1 12.3	3 11.0	4 23.3
ANS	0	255	255	0	5	5	0.0	5 14.3	5 14.3
ANTH	9	0	9	1	0	1	1.6	0.0	1.6
ASTR	0	91	91	0	3	3	0.0	1 1.7	1 1.7
BECBS	0	78	78	0	4	4	0.0	1 28.5	1 28.5
BOT	0	13	13	0	1	1	0.0	4.2	4.2
CCCHE	0	2	2	0	1	1	0.0	4.4	4.4
CCDME	3	0	3	1	0	1	0.6	0.0	0.6
CCENE	0	37	37	0	1	1	0.0	3 26.6	3 26.6
CE	718	694	1412	7	31	38	4 26.1	22 23.0	26 49.1
CERE	0	54	54	0	1	1	0.0	58.2	58.2
CHE	12	1576	1588	2	44	46	3.0	34 4.2	34 7.3
CRC	0	8	8	0	1	1	0.0	7.3	7.3
CURLA	0	10	10	0	1	1	0.0	55.6	55.6
DCS	668	134	802	4	10	14	3 58.7	2 41.3	6 40.1
DOW	0	26	26	0	1	1	0.0	17.3	17.3
DS	0	24	24	0	1	1	0.0	8.9	8.9
DUE	0	6	6	0	1	1	0.0	23.2	23.2
ECON	0	57	57	0	4	4	0.0	1 22.3	1 22.3
ED	0	31	31	0	6	6	0.0	36.3	36.3
EDADM	0	1	1	0	1	1	0.0	10.0	10.0
EDPSY	20	14	34	1	1	2	12.1	19.3	31.4
EDTES	0	5	5	0	1	1	0.0	25.6	25.6
EE	620	430	1050	6	17	23	1 42.8	8 23.1	10 6.0
ENGH	240	0	240	1	0	1	41.1	0.0	41.1
ENTOM	0	11	11	0	1	1	0.0	1.7	1.7
GENE	15	10	25	1	1	2	4.1	5.0	9.2
GEOG	0	6	6	0	1	1	0.0	1.1	1.1
GEOL	0	54	54	0	2	2	0.0	31.3	31.3
GSBA	197	1	198	3	1	4	1 4.3	0.7	1 5.0

7094 Table III October 1966 Continued

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
HEC	0	6	6	0	2	2	0.0	10.7	10.7
HORT	0	75	75	0	3	3	0.0	1 4.3	1 4.3
ICR	0	161	161	0	4	4	0.0	3 34.1	3 34.1
IE	46	7	53	1	1	2	11.0	4.9	16.0
IED	0	19	19	0	1	1	0.0	9.7	9.7
IGPA	0	6	6	0	1	1	0.0	2.3	2.3
ILR	0	72	72	0	3	3	0.0	58.3	58.3
INADM	0	7	7	0	1	1	0.0	0.4	0.4
IREC	0	99	99	0	3	3	0.0	24.2	24.2
MATH	4721	0	4721	4	0	4	12 45.1	0.0	12 45.1
MATRL	0	326	326	0	14	14	0.0	8 19.7	8 19.7
ME	1588	543	2131	16	21	37	6 13.4	18 57.1	25 10.5
MMPE	0	121	121	0	4	4	0.0	31.7	31.7
MUSIC	0	72	72	0	1	1	0.0	1 39.5	1 39.5
NHS	0	79	79	0	3	3	0.0	2 15.8	2 15.8
NUCE	13	227	240	1	8	9	27.5	5 58.1	6 25.7
OIR	0	104	104	0	1	1	0.0	3 53.7	3 53.7
PEM	0	19	19	0	1	1	0.0	14.6	14.6
PHYB	0	153	153	0	6	6	0.0	1 43.1	1 43.1
PHYCS	99	1172	1271	2	18	20	22.1	29 35.6	29 57.7
PHYSL	0	60	60	0	2	2	0.0	41.0	41.0
PHYX	0	2225	2225	0	11	11	0.0	124 4.5	124 4.5
POLS	0	25	25	0	4	4	0.0	1 28.2	1 28.2
PSYCH	89	717	806	3	24	27	1 14.4	15 30.0	16 44.5
SCONS	0	49	49	0	1	1	0.0	23.2	23.2
SCS	0	15	15	0	1	1	0.0	19.0	19.0
SGS	0	74	74	0	1	1	0.0	1 24.7	1 24.7
SOC	96	2	98	1	2	3	46.9	0.3	47.3
SRL	0	35	35	0	2	2	0.0	39.5	39.5
SWS	0	223	223	0	15	15	0.0	2 43.1	2 43.1
TAM	34	198	232	3	14	17	11.3	2 42.9	2 54.2
VPP	0	44	44	0	1	1	0.0	12.2	12.2
VTED	0	9	9	0	2	2	0.0	6.7	6.7
WPGU	0	9	9	0	1	1	0.0	8.3	8.3

7094 Table III October 1966 Continued

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T adn E[2]	Res	Total	T and E[2]	Res	Total
XSSS[3]	0	164	164	0	1	1	0.0	1 11.5	1 11.5
ZOOL	4	104	108	1	3	4	3.1	24.3	27.4
Subtotal	9921	11429	21350	69	360	429	38 53.3	329 02.2	367 55.6
DCSSYS[4]	0	1356	1356	0	19	19	0.0	20 55.6	20 55.6
XDCS[5]	0	37	37	0	1	1	0.0	1 20.5	1 20.5
SSUAD[6]	0	329	329	0	2	2	0.0	5 27.1	5 27.1
Total	9921	13151	23072	69	382	451	38 53.3	356 45.4	395 38.8

1 See list of departmental codes following
2 Training and Education
3 Special Short Shots
4 System Improvement and Modifications
5 System Updating
6 University Administrative Overhead Use

Table I - IBM 1401-I

Summary of Use

November, 1966

Scheduled Engineering	1:00
Unscheduled Engineering	3:47
Maintenance	13:31
7094 Preparation	509:23
List/Reproduce	14:10
Code Check	4:48
Tape Dump	1:11
SMP	9:45
Idle	24:28
Total	582:03

Table II - IBM 1401-I

Summary of Machine Errors

November, 1966

1401 Main Frame	2
1402 Card Reader Punch	2
1403 Printer	1
Total	5

Table I - IBM 1401-II

Summary of Use

November, 1966

Scheduled Engineering	3:26
Unscheduled Engineering	5:25
Maintenance	9:48
7094 Preparation	495:12
List/Reproduce	17:33
Code Check	7:58
Tape Duplication	2:29
Tape Dump	15:25
Idle	35:75
Total	593:28

Table II - IBM 1401-II

Summary of Machine Errors

November, 1966

1401 Main Frame	1
1402 Card Reader Punch	2
1403 Printer	2
Total	5

Table I - IBM 1401-IV

Summary of Use

November, 1966

Scheduled Engineering			1:00
7094 Usage			
	7094 Preparation	19:15	
	Code Check	:50	
	List/Reproduce	3:50	
	Tape Dump	:20	
	SMP	2:48	
	Total		27:03
Illiac Usage			
	Illiac Preparation	3:00	
	Code Check	15:15	
	List	2:40	
	Other	2:55	
	Total		23:50
		Total for Month	51:53

Table I - IBM 7094

Summary of Use

November, 1966

Scheduled Engineering				28:03
Unscheduled Engineering				12:14
Maintenance				16:22
Tape Test				:19
Air Conditioning				8:05
Idle				28:48
Miscellaneous (Operator training, tape rewind, system tape mounting, rerun of failing problems, tape skipping, destruction of clock reading)				95:01
Total Use				
Training and Education			53:34	
University Administrative Overhead Use			8:42	
System Modification and Improvement			24:19	
System Updating			1:12	
Customer Use				
In System		296:06		
Relinquish				
AGEC	:58			
PHYX	17:49			
Relinquish Total		18:47		
Special Short Shots		:42		
Customer Use Total			315:35	
			Total Use	403:22
			Total Time On	592:14

Table II - IBM 7094

Summary of Machine Errors

November, 1966

740 CRT	1
7302 Core Storage	3
Air Conditioning	2
Total	6

7094 Table III November 1966

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
AAE	344	113	457	7	5	12	2 28.7	1 57.2	4 25.9
ADMRE	0	2	2	0	1	1	0.0	2.3	2.3
ADV	0	73	73	0	1	1	0.0	2 54.1	2 54.1
AGE	5	185	190	2	7	9	10.6	2 25.4	2 36.1
AGEC	25	172	197	1	8	9	3.8	5 9.1	5 13.0
AGRON	217	114	331	1	11	12	1 15.2	1 45.1	3 0.3
ANS	0	236	236	0	4	4	0.0	3 49.6	3 49.6
ANTH	11	0	11	1	0	1	1 52.9	0.0	1 52.9
ASTR	0	93	93	0	4	4	0.0	59.4	59.4
BECBS	0	231	231	0	3	3	0.0	3 27.2	3 27.2
BINRE	0	3	3	0	1	1	0.0	4.0	4.0
CCDME	6	1	7	1	1	2	1.6	0.2	1.9
CCENE	0	60	60	0	1	1	0.0	6 4.7	6 4.7
CE	629	805	1434	7	36	43	4 23.2	17 54.8	22 18.1
CERE	7	6	13	1	1	2	1.7	13.5	15.2
CHE	111	1517	1628	5	43	48	30.8	45 51.1	46 22.0
CP	1	0	1	1	0	1	0.1	0.0	0.1
CRC	0	40	40	0	1	1	0.0	47.5	47.5
CURLA	0	14	14	0	2	2	0.0	26.5	26.5
DCS	618	76	694	6	5	11	5 13.2	54.1	6 7.4
DOW	0	16	16	0	1	1	0.0	18.2	18.2
DS	0	118	118	0	3	3	0.0	2 12.5	2 12.5
DUE	0	10	10	0	1	1	0.0	6.7	6.7
ECON	0	118	118	0	5	5	0.0	1 53.8	1 53.8
ED	0	52	52	0	7	7	0.0	1 34.9	1 34.9
EDADM	0	20	20	0	2	2	0.0	39.1	39.1
EDPSY	27	3	30	1	1	2	5.8	0.7	6.5
EDTES	0	1	1	0	1	1	0.0	8.0	8.0
EE	1085	465	1550	10	15	25	3 39.9	13 46.8	17 26.8
ENGH	155	0	155	1	0	1	33.5	0.0	33.5
ENTOM	0	9	9	0	2	2	0.0	9.4	9.4
FOR	0	23	23	0	2	2	0.0	8.9	8.9
GENE	6	6	12	1	1	2	0.7	3.1	3.9

7094 Table III November 1966 Continued

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
GEOG	0	33	33	0	3	3	0.0	10.6	10.6
GEOL	0	58	58	0	2	2	0.0	27.5	27.5
GSBA	291	7	298	4	2	6	2 47.7	6.9	2 54.7
HEC	0	6	6	0	1	1	0.0	29.9	29.9
HLTHS	0	8	8	0	1	1	0.0	1 5.8	1 5.8
HORT	0	53	53	0	5	5	0.0	57.4	57.4
ICR	0	145	145	0	4	4	0.0	3 4.7	3 4.7
IE	59	11	70	3	1	4	11.7	10.3	22.1
IGPA	0	12	12	0	1	1	0.0	7.0	7.0
ILR	0	58	58	0	4	4	0.0	50.4	50.4
IREC	0	49	49	0	3	3	0.0	34.3	34.3
MATH	4469	23	4492	3	1	4	19 17.6	19.3	19 36.9
MATRL	0	374	374	0	15	15	0.0	9 34.1	9 34.1
ME	1818	434	2252	18	13	31	7 26.8	11 37.4	19 4.3
MKTG	16	0	16	1	0	1	29.8	0.0	29.8
MMPE	0	82	82	0	4	4	0.0	52.7	52.7
MUSIC	0	130	130	0	1	1	0.0	3 15.1	3 15.1
NHS	0	119	119	0	2	2	0.0	1 47.3	1 47.3
NUCE	31	151	182	2	7	9	8.9	2 44.9	2 53.8
OIR	0	189	189	0	1	1	0.0	4 11.5	4 11.5
PEM	0	42	42	0	3	3	0.0	21.5	21.5
PHYB	0	75	75	0	5	5	0.0	1 25.1	1 25.1
PHYCS	164	1103	1267	5	22	27	1 6.1	26 43.6	27 49.7
PHYSL	0	61	61	0	3	3	0.0	23.5	23.5
PHYX	0	2078	2078	0	12	12	0.0	99 29.5	99 29.5
PLPA	0	10	10	0	1	1	0.0	3.0	3.0
POLS	0	38	38	0	3	3	0.0	48.3	48.3
PSYCH	40	637	677	3	23	26	23.3	13 59.0	14 22.4
REC	0	3	3	0	1	1	0.0	0.7	0.7
SCONS	0	86	86	0	1	1	0.0	53.0	53.0
SCS	0	1	1	0	1	1	0.0	0.1	0.1
SGS	0	108	108	0	1	1	0.0	1 4.3	1 4.3
SOC	97	7	104	1	1	2	52.9	9.2	1 2.2
SOCW	0	22	22	0	2	2	0.0	2 29.8	2 29.8
SPCH	0	12	12	0	1	1	0.0	1 17.3	1 17.3
SPED	0	6	6	0	1	1	0.0	8.6	8.6

7094 Table III November 1966 Continued

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
SRL	0	19	19	0	2	2	0.0	17.8	17.8
SWS	0	266	266	0	16	16	0.0	3 46.6	3 46.6
TAM	85	246	331	6	13	19	24.0	2 0.5	2 24.6
VPH	0	2	2	0	1	1	0.0	0.6	0.6
VPP	0	19	19	0	1	1	0.0	12.1	12.1
WPGU	0	4	4	0	1	1	0.0	7.9	7.9
XSSS	0	122	122	0	1	1	0.0	41.5	41.5
ZOOL	4	189	193	1	5	6	2.0	51.7	53.8
Subtotal	10321	11680	22001	93	368	461	53 33.8	315 34.8	369 8.7
DCSSYS[4]	0	1352	1352	0	21	21	0.0	24 19.0	24 19.0
XDCS[5]	0	41	41	0	1	1	0.0	1 11.9	1 11.9
SSUAD[6]	0	260	260	0	2	2	0.0	8 42.4	8 42.4
Total	10321	13333	23654	93	392	485	53 33.8	349 48.1	403 22.0

1 See list of departmental codes following
2 Training and Education
3 Special Short Shots
4 System Improvement and Modifications
5 System Updating
6 University Administrative Overhead Use

Table I - IBM 1401-I

Summary of Use

December, 1966

Scheduled Engineering	2:45
Unscheduled Engineering	7:45
Maintenance	11:43
7094 Preparation	502:45
List/Reproduce	17:41
Code Check	5:39
Tape Dump	4:13
SMP	2:48
Idle	19:32
Total	574:51

Table II - IBM 1401-I

Summary of Machine Errors

December, 1966

1401 Main Frame	4
1402 Card Reader Punch	1
729V Tape Drives	2
Total	7

Table I - IBM 1401-II

Summary of Use

December, 1966

Scheduled Engineering	4:15
Unscheduled Engineering	10:03
Maintenance	12:16
7094 Preparation	486:42
List/Reproduce	21:39
Code Check	7:05
Tape Dump	6:32
SMP	2:44
Idle	28:05
Total	579:21

Table II - IBM 1401-II

Summary of Machine Errors

December, 1966

1401 Main Frame	4
1402 Card Reader Punch	1
1403 Printer	1
Total	6

Table I - IBM 1401-IV

Summary of Use

December, 1966

Unscheduled Engineering		:32
Maintenance		:20
7094 Preparation		14:08
List/Reproduce		5:05
Tape Dump		:54
SMP		:26
Illiac II Preparation		4:10
Other		12:00
	Total	37:35

Table I - IBM 7094

Summary of Use

December, 1966

Scheduled Engineering				28:13
Unscheduled Engineering				3:06
Machine Maintenance				14:49
Tape Test				:31
Air Conditioning				:10
Idle				47:31
Miscellaneous (Operator training, tape rewind, system tape mounting, rerun of failing problems, tape skipping, destruction of clock reading)				79:48
TOTAL USE				
Training and Education			68:52	
University Administrative Overhead Use			6:31	
System Modification and Improvement			17:14	
System Updating			:25	
Customer Use				
In system		299:31		
Relinquish				
AGEC	2:18			
GSBA	:19			
PHYX	9:51			
Relinquish Total		12:28		
Special Short Shots		:56		
Customer Use Total			312:55	
		Total Use		405:57
		Total Time On		580:05

Table II - IBM 7094

Summary of Errors

December, 1966

716 Printer	1
7094 Main Frame	1
721 Card Punch	1
Total	3

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E^2	Res	Total	T and E^2	Res	Total	T and E^2	Res	Total
AAE	145	164	309	6	3	9	3 33.4	2 38.5	6 12.0
ADMRE	0	1	1	0	1	1	0.0	2.7	2.7
ADV	0	6	6	0	1	1	0.0	19.8	19.8
AGE	75	159	234	3	7	10	3 4.9	2 4.7	5 9.6
AGEC	55	152	207	3	9	12	13.0	3 59.7	4 12.7
AGRON	168	136	304	1	12	13	1 9.2	1 14.3	2 23.6
ANS	0	103	103	0	4	4	0.0	1 26.8	1 26.8
ANTH	11	1	12	1	1	2	17.5	1 56.0	2 13.6
ASTR	0	143	143	0	6	6	0.0	1 7.6	1 7.6
BECBS	0	218	218	0	4	4	0.0	1 50.0	1 50.0
CCDME	10	1	11	1	1	2	12.5	0.2	12.8
CCENE	0	98	98	0	1	1	0.0	9 53.8	9 53.8
CCPHC	16	0	16	1	0	1	26.0	0.0	26.0
CCSCS	0	7	7	0	1	1	0.0	1.4	1.4
CE	835	762	1597	7	36	43	6 21.8	20 2.5	26 24.4
CERE	1	0	1	1	0	1	0.2	0.0	0.2
CHE	141	1298	1439	6	45	51	27.7	43 10.6	43 38.4
CRC	0	46	46	0	1	1	0.0	34.4	34.4
CURLA	0	68	68	0	2	2	0.0	37.1	37.1
DCS	991	80	1071	5	6	11	10 43.4	1 11.0	11 54.4
DOW	0	35	35	0	1	1	0.0	23.7	23.7
DS	0	118	118	0	3	3	0.0	4 46.6	4 46.6
ECON	0	83	83	0	6	6	0.0	1 35.8	1 35.8
ED	0	101	101	0	9	9	0.0	1 49.7	1 49.7
EDADM	0	33	33	0	2	2	0.0	24.7	24.7
EDPSY	27	4	31	1	1	2	8.5	1.0	9.5
EE	966	417	1383	12	15	27	4 37.5	8 28.9	13 6.5
ENGH	306	0	306	1	0	1	1 42.9	0.0	1 42.9
ENTOM	0	3	3	0	1	1	0.0	11.2	11.2
FOR	0	9	9	0	3	3	0.0	1.9	1.9
GENE	105	0	105	2	0	2	27.8	0.0	27.8
GEOG	11	21	32	1	3	4	1.6	16.9	18.5
GEOL	0	25	25	0	2	2	0.0	9.1	9.1
GSBA	659	0	659	4	0	4	10 48.6	0.0	10 48.6

7094 Table III December 1966 Continued

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
HEC	0	3	3	0	2	2	0.0	4.6	4.6
HED	0	18	18	0	1	1	0.0	39.8	39.8
HORT	0	67	67	0	3	3	0.0	57.7	57.7
ICR	0	111	111	0	3	3	0.0	3 14.5	3 14.5
IE	232	8	240	3	1	4	54.1	3.4	57.5
IED	0	15	15	0	1	1	0.0	48.2	48.2
IGPA	0	12	12	0	1	1	0.0	11.3	11.3
ILR	0	39	39	0	1	1	0.0	33.2	33.2
INADM	0	1	1	0	1	1	0.0	3.0	3.0
IREC	0	16	16	0	2	2	0.0	1 51.5	1 51.5
MATH	3338	17	3355	3	1	4	13 34.6	10.4	13 45.1
MATRL	0	452	452	0	15	15	0.0	14 57.7	14 57.7
ME	1205	224	1429	17	8	25	6 8.5	3 41.2	9 49.7
MKTG	5	0	5	1	0	1	0.8	0.0	0.8
MMPE	0	117	117	0	4	4	0.0	1 13.1	1 13.1
MUSIC	0	6	6	0	1	1	0.0	6.1	6.1
NHS	0	55	55	0	2	2	0.0	1 16.6	1 16.6
NUCE	13	193	206	1	8	9	2.8	4 29.5	4 32.3
OIR	0	131	131	0	1	1	0.0	3 44.2	3 44.2
PEM	0	19	19	0	3	3	0.0	12.6	12.6
PHYB	0	48	48	0	7	7	0.0	33.8	33.8
PHYCS	44	1103	1147	4	18	22	17.7	26 22.7	26 40.4
PHYSL	0	49	49	0	2	2	0.0	19.1	19.1
PHYX	0	2063	2063	0	12	12	0.0	105 15.7	105 15.7
PLPA	0	3	3	0	1	1	0.0	1.1	1.1
POLS	0	60	60	0	3	3	0.0	1 31.7	1 31.7
PSYCH	118	591	709	4	23	27	1 12.2	14 46.6	15 58.8
REC	0	5	5	0	1	1	0.0	1.8	1.8
SCONS	0	133	133	0	1	1	0.0	2 58.7	2 58.7
SGS	0	47	47	0	1	1	0.0	55.2	55.2
SOC	21	52	73	1	3	4	8.5	1 14.2	1 22.8
SOCW	0	5	5	0	1	1	0.0	35.8	35.8
SPED	0	4	4	0	1	1	0.0	7.7	7.7
SRL	0	46	46	0	1	1	0.0	41.5	41.5
SWS	0	250	250	0	17	17	0.0	3 17.6	3 17.6

7094 Table III December 1966 Continued

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
TAM	172	201	373	6	10	16	1 55.6	2 48.6	4 44.2
USGS	0	2	2	0	1	1	0.0	0.3	0.3
VPH	0	23	23	0	1	1	0.0	8.9	8.9
VPP	0	24	24	0	1	1	0.0	8.0	8.0
VTED	0	2	2	0	1	1	0.0	0.4	0.4
WPGU	0	4	4	0	1	1	0.0	8.0	8.0
XSSS	0	87	87	0	1	1	0.0	55.6	55.6
ZOOL	14	258	272	1	4	5	18.8	1 18.7	1 37.6
Subtotal	9684	10856	20540	97	358	455	68 51.7	312 54.9	381 46.6
DCSSYS[4]	0	1010	1010	0	18	18	0.0	17 14.3	17 14.3
XDCS[5]	0	18	18	0	1	1	0.0	25.0	25.0
SSUAD[6]	0	311	311	0	2	2	0.0	6 30.7	6 30.7
Total	9684	12195	21879	97	379	476	68 51.7	337 4.9	405 56.6

1 See list of departmental codes following
2 Training and Education
3 Special Short Shots
4 System Improvement and Modifications
5 System Updating
6 University Administrative Overhead Use

Quarterly Summary of Departmental Running Time

October, November, December, 1966

Dept[1]	Number of Runs T and E[2]	Number of Runs Res	Number of Runs Total	Number of Specs T and E[2]	Number of Specs Res	Number of Specs Total	7094 Usage in Hours-Minutes T and E[2]	7094 Usage Res	7094 Usage Total
AAE	816	403	1219	20	12	32	9 1.9	6 50.4	15 52.3
ASTR	0	327	327	0	13	13	0.0	3 8.8	3 8.8
ADMRE	0	3	3	0	2	2	0.0	5.1	5.1
ADV	0	102	102	0	3	3	0.0	3 35.7	3 35.7
ANS	0	594	594	0	13	13	0.0	10 30.7	10 30.7
ANTH	31	1	32	3	1	4	2 12.1	1 56.0	4 8.1
AGE	86	466	552	7	22	29	3 26.5	5 57.3	9 23.8
AGEC	80	478	558	4	28	32	16.8	14 0.3	14 17.2
AGRON	781	405	1186	3	36	39	3 36.8	6 10.5	9 47.3
BECBS	0	527	527	0	11	11	0.0	6 45.8	6 45.8
BOT	0	13	13	0	1	1	0.0	4.2	4.2
BINRE	0	3	3	0	1	1	0.0	4.0	4.0
CCCHE	0	2	2	0	1	1	0.0	4.4	4.4
CCDME	19	2	21	3	2	5	14.8	0.5	15.4
CCENE	0	195	195	0	3	3	0.0	19 25.2	19 25.2
CCPHC	16	0	16	1	0	1	26.0	0.0	26.0
CCSCS	0	7	7	0	1	1	0.0	1.4	1.4
CURLA	0	92	92	0	5	5	0.0	1 59.3	1 59.3
CE	2182	2261	4443	21	103	124	15 11.2	60 20.5	75 31.7
CERE	8	60	68	2	2	4	2.0	1 11.8	1 13.8
CP	1	0	1	1	0	1	0.1	0.0	0.1
CHE	264	4391	4655	13	132	145	1 1.7	123 6.1	124 7.8
CRC	0	94	94	0	3	3	0.0	1 29.3	1 29.3
DS	0	260	260	0	7	7	0.0	7 8.2	7 8.2
DCS	2277	290	2567	15	21	36	19 55.4	4 46.5	24 42.0
DUE	0	16	16	0	2	2	0.0	29.9	29.9
DOW	0	77	77	0	3	3	0.0	59.3	59.3
ECON	0	258	258	0	15	15	0.0	4 52.0	4 52.0
ED	0	184	184	0	22	22	0.0	4 1.0	4 1.0
EDADM	0	54	54	0	5	5	0.0	1 13.9	1 13.9
EDPSY	74	21	95	3	3	6	26.5	21.1	47.6
EDTES	0	6	6	0	2	2	0.0	33.7	33.7
EE	2671	1312	3983	28	47	75	10 0.4	30 38.9	40 39.4
ENGH	701	0	701	3	0	3	2 57.7	0.0	2 57.7

Quarterly Summary of Departmental Running Time

October, November, December, 1966 Continued

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T and E[2]	Res	Total	T and E[2]	Res	Total
ENTOM	0	23	23	0	4	4	0.0	22.4	22.4
FOR	0	32	32	0	5	5	0.0	10.9	10.9
GSBA	1147	8	1155	11	3	14	14 40.7	7.6	14 48.4
GENE	126	16	142	4	2	6	32.8	8.2	41.1
GEOG	11	60	71	1	7	8	1.6	28.6	30.3
GEOL	0	137	137	0	6	6	0.0	1 8.1	1 8.1
HLTHS	0	8	8	0	1	1	0.0	1 5.8	1 5.8
HEC	0	15	15	0	5	5	0.0	45.3	45.3
HED	0	18	18	0	1	1	0.0	39.8	39.8
HORT	0	195	195	0	11	11	0.0	2 59.5	2 59.5
ICR	0	417	417	0	11	11	0.0	9 53.3	9 53.3
ILR	0	169	169	0	8	8	0.0	2 22.0	2 22.0
IE	337	26	363	7	3	10	1 16.9	18.8	1 35.7
INADM	0	8	8	0	2	2	0.0	3.5	3.5
IED	0	34	34	0	2	2	0.0	58.0	58.0
IGPA	0	30	30	0	3	3	0.0	20.8	20.8
IREC	0	164	164	0	8	8	0.0	2 50.2	2 50.2
MATH	12528	40	12568	10	2	12	45 37.4	29.7	46 7.2
MATRL	0	1152	1152	0	44	44	0.0	32 51.5	32 51.5
MKTG	21	0	21	2	0	2	30.7	0.0	30.7
MMPE	0	320	320	0	12	12	0.0	2 37.7	2 37.7
MUSIC	0	208	208	0	3	3	0.0	5 0.8	5 0.8
ME	4611	1201	5812	51	42	93	19 48.8	34 15.7	54 4.6
NUCE	57	571	628	4	23	27	39.4	13 12.6	13 52.0
NHS	0	253	253	0	7	7	0.0	5 19.9	5 19.9
OIR	0	424	424	0	3	3	0.0	11 49.5	11 49.5
PSYCH	247	1945	2192	10	70	80	2 50.0	44 15.7	47 5.8
PLPA	0	13	13	0	2	2	0.0	4.2	4.2
PEM	0	80	80	0	7	7	0.0	48.8	48.8
POLS	0	123	123	0	10	10	0.0	3 48.4	3 48.4

Quarterly Summary of Departmental Running Time

October, November, December, 1966 Continued

Dept[1]	Number of Runs			Number of Specs			7094 Usage in Hours-Minutes		
	T and E[2]	Res	Total	T adn E[2]	Res	Total	T and E[2]	Res	Total
PHYB	0	276	276	0	18	18	0.0	3 42.1	3 42.1
PHYCS	307	3378	3685	11	58	69	1 46.0	82 42.0	84 28.0
PHYSL	0	170	170	0	7	7	0.0	1 23.7	1 23.7
PHYX	0	6366	6366	0	35	35	0.0	328 49.9	328 49.9
REC	0	8	8	0	2	2	0.0	2.6	2.6
SCONS	0	268	268	0	3	3	0.0	4 15.0	4 15.0
SCS	0	16	16	0	2	2	0.0	19.1	19.1
SOC	214	61	275	3	6	9	1 48.5	1 23.8	3 12.4
SOCW	0	27	27	0	3	3	0.0	3 5.6	3 5.6
SWS	0	739	739	0	48	48	0.0	9 47.5	9 47.5
SPCH	0	12	12	0	1	1	0.0	1 17.3	1 17.3
SPED	0	10	10	0	2	2	0.0	16.3	16.3
SGS	0	229	229	0	3	3	0.0	3 24.4	3 24.4
SRL	0	100	100	0	5	5	0.0	1 39.0	1 39.0
TAM	291	645	936	15	37	52	2 31.0	7 32.2	10 3.2
USGS	0	2	2	0	1	1	0.0	0.3	0.3
VTED	0	11	11	0	3	3	0.0	7.1	7.1
VPH	0	25	25	0	2	2	0.0	9.5	9.5
VPP	0	87	87	0	3	3	0.0	32.5	32.5
WPGU	0	17	17	0	3	3	0.0	24.4	24.4
XSSS	0	373	373	0	3	3	0.0	2 48.7	2 48.7
ZOOL	22	551	573	3	12	15	23.9	2 34.9	2 58.9
Subtotal	29926	33965	63891	259	1086	1345	161 18.8	957 31.8	1118 50.7
DCSSY[4]	0	3718	3718	0	58	58	0.0	62 29.0	62 29.0
XDCS[5]	0	96	96	0	3	3	0.0	2 57.5	2 57.5
SSUAD[6]	0	900	900	0	6	6	0.0	20 40.3	20 40.3
Total	29926	38679	68605	259	1153	1412	161 18.8	1043 38.6	1204 57.5

1 See list of departmental codes following
2 Training and Education
3 Special Short Shots
4 System Improvement and Modifications
5 System Updating

LIST OF DEPARTMENT CODES

IF YOUR DEPARTMENT OR OFFICE DOES NOT APPEAR ON THIS LIST, PLEASE WRITE ITS FULL NAME IN THE DEPARTMENT FIELD (B) ON THE PROBLEM SPECIFICATION FORM EVEN THOUGH IT WILL REQUIRE MORE THAN 6 CHARACTERS.

ACCY	ACCOUNTANCY
ADMREC	ADMISSIONS AND RECORDS
ADV	ADVERTISING
AAE	AERONAUTICAL AND ASTRONAUTICAL ENGINEERING
AGEC	AGRICULTURAL ECONOMICS
AGED	AGRICULTURAL EDUCATION
AGE	AGRICULTURAL ENGINEERING
AGREXT	AGRICULTURAL EXTENSION
AGR	AGRICULTURE
AGRON	AGRONOMY
ANS	ANIMAL SCIENCE
ANTH	ANTHROPOLOGY
ARCH	ARCHITECTURE
ART	ART
ASTR	ASTRONOMY
BIOPH	BIOPHYSICS
BOT	BOTANY
BCMPL	BUREAU OF COMMUNITY PLANNING
BECBSR	BUREAU OF ECONOMIC AND BUSINESS RESEARCH
BEDRES	BUREAU OF EDUCATIONAL RESEARCH
GSBA	BUSINESS ADMINISTRATION, GRADUATE SCHOOL
CZR	CENTER FOR ZOONOSES RESEARCH
CERE	CERAMIC ENGINEERING
CHE	CHEMISTRY AND CHEMICAL ENGINEERING
CRC	CHILDREN'S RESEARCH CENTER
CP	CITY PLANNING
CE	CIVIL ENGINEERING
CCARCH	ARCHITECTURE (CHICAGO CIRCLE)
COMM	COMMUNICATIONS
CSL	COORDINATED SCIENCE LABORATORY
DS	DAIRY SCIENCE
DT	DAIRY TECHNOLOGY
DNSTUD	DEAN OF STUDENTS
DCS	DEPARTMENT OF COMPUTER SCIENCE
DGS	DIVISION OF GENERAL STUDIES L A S
DUE	DIVISION OF UNIVERSITY EXTENSION
ECON	ECONOMICS
ED	EDUCATION
EDPSY	EDUCATION PSYCHOLOGY
EDADM	EDUCATIONAL ADMINISTRATION AND SUPERVISION
EDTEST	EDUCATIONAL TESTING
EE	ELECTRICAL ENGINEERING

ENGLSH	ENGLISH
EDC	EXTENSION DIVISION, COUNSELING
FIN	FINANCE
FT	FOOD SCIENCE
FOR	FORESTRY
GENE	GENERAL ENGINEERING
GEOG	GEOGRAPHY
GEOL	GEOLOGY
GRDCOL	GRADUATE COLLEGE
GSBA	GRADUATE SCHOOL OF BUSINESS ADMINISTRATION
HED	HEALTH EDUCATION
HLTHSV	HEALTH SERVICE
HEC	HOME ECONOMICS
HORT	HORTICULTURE
ILLDMH	ILLINOIS DEPARTMENT OF MENTAL HEALTH
INADM	INDUSTRIAL ADMINISTRATION
IED	INDUSTRIAL EDUCATION
IE	INDUSTRIAL ENGINEERING
IREC	INSTITUTE FOR RESEARCH ON EXCEPTIONAL CHILDREN
ICR	INSTITUTE OF COMMUNICATIONS RESEARCH
IGPA	INSTITUTE OF GOVERNMENT AND PUBLIC AFFAIRS
ILR	INSTITUTE OF LABOR AND INDUSTRIAL RELATIONS
LIR	LABOR AND INDUSTRIAL RELATIONS
LAW	LAW
LIBS	LIBRARY SCIENCE
MKTG	MARKETING
MATRL	MATERIALS RESEARCH LABORATORY
MATH	MATHEMATICS
ME	MECHANICAL ENGINEERING
MRL	MEDICAL RESEARCH LAB
MEDIC	MEDICINE
MRHA	MEN'S RESIDENCE HALL ASSOCIATION
MRHARC	MEN'S RESIDENCE HALL ASSOCIATION ROCKET CLUB
MMPE	MINING, METALLURGY AND PETROLEUM ENGINEERING
MUSIC	MUSIC
NHS	NATURAL HISTORY SURVEY
NUCE	NUCLEAR ENGINEERING
OIR	OFFICE OF INSTRUCTIONAL RESOURCES
PHIL	PHILOSOPHY
PEM	PHYSICAL EDUCATION FOR MEN AND GRADUATE PE
PEW	PHYSICAL EDUCATION FOR WOMEN
PHYX	PHYSICS
PHYSL	PHYSIOLOGY
PLPA	PLANT PATHOLOGY
POLS	POLITICAL SCIENCE
PSYTRY	PSYCHIATRY
PSYCH	PSYCHOLOGY
REC	RECREATION
SHCBRC	SMALL HOMES COUNCIL, BUREAU OF RESIDENTIAL CONSTRUCTION
SOCW	SOCIAL WORK
SOC	SOCIOLOGY

SCONS	SOIL CONSERVATION SERVICE
SPCH	SPEECH AND THEATRE
SGS	STATE GEOLOGICAL SURVEY
SWS	STATE WATER SURVEY
SSU	STATISTICAL SERVICES UNIT
SCS	STUDENT COUNSELING SERVICE
SRL	SURVEY RESEARCH LABORATORY
TAM	THEORETICAL AND APPLIED MECHANICS
USGS	U.S. GEOLOGICAL SERVICE
UNIHI	UNIVERSITY HIGH SCHOOL
VAH	VETERINARY ANATOMY AND HISTOLOGY
VCM	VETERINARY CLINICAL MEDICINE
VMS	VETERINARY MEDICAL SCIENCE
VPH	VETERINARY PATHOLOGY AND HYGIENE
VPP	VETERINARY PHYSIOLOGY AND PHARMACOLOGY
VTED	VOCATIONAL AND TECHNICAL EDUCATION
WPGU	WPGU RADIO STATION
ZOOL	ZOOLOGY

8. PROBLEM SPECIFICATIONS

8.1 Research Problem Specifications

During the fourth quarter of 1966, 136 problem specifications were submitted to the Department for computation. The following brief descriptions of these problems have been prepared for inclusion in this report by those submitting them. T indicates a calculation associated with a thesis.

2253-6ø004 T Theoretical and Applied Mechanics. Analysis of Combined Periods and Random Mechanical Vibrations. This project concerns itself with the response of a linear mechanical system to combined random and periodic forcing functions, and the determination of the relative magnitudes of random and periodic components of forcing functions at which a "deterministic" solution (by means of Fourier series) provides more information than a corresponding statistical analysis. Techniques used will be Fourier analysis of a given forcing function, inversion of an n x n ($n \leq 10$) matrix with complex elements, and the use of numerical integration techniques to solve complex combined periodic and random probability density functions. All data will be artificially generated by the computer. It is hoped that the analysis will provide insight for development of satisfactory, short analysis techniques for combined random and periodic vibration. (Richard G. Carlson)

2254-6ø006 T Civil Engineering. Interaction of Structural Frames with Filler Walls. The interaction of structural frames with filler walls is to be investigated by means of an analog model for the structural system. The analysis will consist of a recursive generation of simultaneous linear algebraic equations, solution of these equations by Gauss elimination to yield deflections at discrete points, and the computation of associated stresses. The resulting deflections for the structural system will enable a load-deflection relationship to be established, and thus the behavior of the system under the action of increasing loads will be defined. (J. P. Fedorkiw)

2255-6ø007 Division of University Extension. Police Training Survey. This project is designed to evaluate the first ten years of operation of the Police Training Institute of the University of Illinois. Data were collected

through questionnaires sent to each individual who attended a P.T.I. Basic Training Course and to each Department in the State which sent men to one or more of the courses. On the basis of these data, it will be possible to reorganize and strengthen the curriculum of the Institute so that it can better serve its function of training law enforcement officers of the State. The computer will be required in securing frequency counts, percentages, and some statistical significance test results (chi square). (Harold Wecke)

2256-6Ø008 Psychology. Relationship of Reaction Time to Galvanic Skin Resistance. A naive subject and an accomplice expressed judgments in response to thirty two questions. To some questions the accomplice, who always announced his answers first, expressed very improbable replies. The subject's decision time and Galvanic Skin Resistance were recorded throughout the experimental session. Control subjects received the same treatment except that the accomplice always expressed very probable answers. In both types of groups measures were taken of "conformity behavior," rejection of the accomplice, devaluation of the issue with which the questions dealt, and underrecall of disagreements.

The computer will be used to run correlations between reaction times and Galvanic Skin Resistance for eight different blocks of "trials." These correlations will be run separately for (a) control subjects; (b) experimental subjects; and (c) six different subsamples of experimental subjects. Ordinary Pearson r will be employed.

The object of the study is to compare results obtained from the use of two measures (reaction time and Galvanic Skin Resistance) which have often been used as indexes of "stress." It is expected that the correlations of the two measures will be a function of the strategy subjects employ in dealing with the situation (e.g, conformity, rejection of the accomplice, etc.). (Ivan D. Steiner)

2257-6Ø009 T Mechanical Engineering. Duct Flow of Ionized Gas. The 7094 will be used to process data which are being obtained from a rectangular duct containing the arc region of a flow of ionized gas. The data will include the temperatures of duct walls, wall cooling water, and incoming gas, the gas flow rate, the electric field, and the electric current. The analysis

includes application of the equations of conservation of mass, momentum, and energy. The results will give the transport properties of the gas as functions of temperature. (Steve Colburn)

2258-6Ø013 Department of Computer Science. ILLIAC IV Simulator. In order to augment the design of the ILLIAC IV (a parallel processing computer) and to prepare programmers and programs prior to the time when the hardware becomes operable, a machine simulator will be developed. It will have all the programming properties of the machine itself, but, of course, it will run at only a fraction of the speed. The simulator will maintain a complete "picture" of the ILLIAC IV registers and memory. "Running" a program will mean the sequencing, interpretation, and execution of instructions from the pseudo-memory (1301 disk). Execution of instructions results in the changing of the "picture" from one state to another. I/O considerations for the sumulator fall into three categories: (1) ILLIAC IV program loading will be from "library" tapes of object code blocks; (2) maintainance of the pseudo-memory on disk; (3) the simulated programs will have some sort of I/O capability, to be determined. It is anticipated that heavy use will be made of this program by those research problems destined to be solved by the ILLIAC IV. (L. E. Anderson)

2259-6Ø014 Department of Computer Science. ILLIAC IV Assembly Program. An assembler program for the ILLIAC IV computer will be developed by this effort. Furthermore, assembly language will be translated and stored on a reserved "library" tape. Data have the form of instruction statements conducive to readability, one on a card. These symbolic statements will be translated, in a one for one manner, to single machine (ILLIAC IV) instructions. Resulting object code will be printed and stored on tape. These blocks of object code may be read into and executed by the ILLIAC IV Simulator program which is being programmed by another effort. (L. E. Anderson)

2260-6Ø015 T Electrical Engineering. Determination of Significant Subsequences of Machine Encoded Speech. This problem deals with the determination of significant patterns in machine encoded speech. If five

different people say the word "one," their exact pronounciations may differ, but the word is still understood. This implies that there is an invariant characteristic to the pronounciation of words. If the spoken words are analyzed by their frequency spectrum as a function of time, some patterns appear. Until now the analysis of these patterns has been done by hand and by intuition. The program to be developed will be able to do this more quickly. If the algorithm is sufficiently simple, a small special purpose computer may be built based upon this algorithm. (John P. Schill)

2261-6Ø027 Chicago Circle Department of Materials Engineering. Foundations of Dynamic Shell Theory. The research involves the investigation of motions of shells and shell type structures without making any *a priori* assumptions regarding the distribution of stresses and displacements over the thickness. The analysis is based on the application of the boundary layer technique to the equations of the three-dimensional theory of orthotropic elasticity. Due to the asymptotic expansion feature of this technique, one obtains both the simplest approximate thin shell theories as well as more elaborate thick shell theories each developed in a consistent and systematic manner. From a comparison with the equations derived by this approach, it will be possible to determine the relative accuracy of the many different thin and thick shell theories existing in the literature, and also show their relation to the exact three-dimensional theory. This comparison can only be carried out by use of a computer, which makes it possible to display the frequency-wave-length spectrum for waves propagating in an infinite shell. (O. E. Widera)

2262-6Ø028 T Educational Administration. Simulated Materials Workshop and Its Effect Upon the Perceptions of the Participants. The *Occupational Characteristics Index*, developed at the University of Illinois, is a forced-choice instrument which asks respondents to describe themselves or others by rank-ordering twenty-one personal traits. For this problem, participants in a simulated materials workshop have used this instrument to describe an administrative-ideal and a self-actual. A post-measure was taken also. A two-way analysis of variance with repeated measures will compare four different clusters (1) between an experimental group and control groups, (2) between pre- and post-measures, and (3) any interaction effect between

the groups and the time of administration. An F-test for homogeneity of variance will be used to compare the variances of each cluster for the pre- and post-testing. (L. A. Stoneburner)

2263-6Ø030 Materials Research Laboratory. Crystal Growth Rates. The problem pertains to a project concerned with the growth of crystals in gloss systems, and involves fitting a theoretical curve to the data. The data are experimental measurements of the growth rate of lead borate crystals from a melt at various temperatures below that of the liquids.
(C. G. Bergeron)

2264-6Ø031 T Education. Computer-Aided Learning and Transfer Effects of Russian Pronunciation. This project is concerned with the parameters which control the retention of verbal learning materials when taught by Computer-Aided Instructional Techniques. The task is to define the minimum necessary conditons for maximum retention and transfer. This kind of information will enable the Computer-Based Instructional System to teach using a minimum of system and student time to the greatest advantage in terms of material learned. The data for this research study were collected by the System for Organizing Content to Review And Teach Educational Subjects, SOCRATES. The analysis of the data will utilize the multiple correlation program in SSUPAC and various analysis of variance programs. The results of this particular research study will contribute to some basic knowledge concerning how students learn under computer control and how much the educator can allow the students' responses to control some of the parameters of this teaching-learning situation.
(Lippert)

2265-6Ø032 T Nuclear Engineering. Neutron Transport in Semi-infinite Media. The total absorbed dose rates at various depths in semi-infinite media due to surface irradiation by neutrons of various energies and angular descriptions will be determined. The Monte Carlo method will be used to generate histories describing the transport of neutrons (and photons produced in neutron interactions) through the media. The information describing the histories will be used to calculate absorbed doses through the use of appropriate conversion factors. ØSR, a Monte Carlo Neutron Transport Code developed at Oak Ridge National Laboratory, will be used.
(Roussin)

2266-6∅033 Materials Research Laboratory. Photoconductivity Stability. In the overall framework of a study of instabilities and nonlinear effects in semiconductors, the stability of a distribution of photoexcited electrons is examined. A solution of the Boltzmann equation for electrons has been obtained analytically. The initial computer program will be designed to compute and plot the complicated formulas for a wide range of parameters. (Hans Stocker)

2267-6∅034 T Nuclear Engineering. Emission of Electrons from Fission Fragments. The problem deals with the emission of beta particles and internal conversion electrons from fission fragments. The time and energy dependence of the low energy beta spectrum will be measured for the following cases: (1) the initiation of a constant fission rate in a clean U^{235} foil; (2) the termination of fissioning in a U^{235} foil close to equilibrium; and (3) following an instantaneous burst of fissions produced by neutrons from a reactor pulse. The energy spectrum of internal conversion electrons emitted in coincidence with fission of U^{235} and Cf^{252} will also be measured. The computer will be used in the analysis of the experimental data and in theoretical calculations for comparison with the experimental results. The theoretical calculations for a single transition in any one fission fragment represent a fairly easy calculation. The computer, however, is required because of the multiplicity of transitions and fission fragments. (N. Tsoulfanidis)

2268-6∅035 T Civil Engineering. Model Study. This problem is associated with a plaster model study of the behavior of underground openings subjected to static loading, being conducted by the rock mechanics group in the Department of Civil Engineering. The computer will be used for two purposes: (1) Data Reduction. This will consist of routine calculations involved in the reduction of data obtained by instrumentation such as dial gages, SR4 gages, and LVDT's in studying the model behavior and defining the properties of the plaster modeling material. (2) Finite-Element Analysis. Using the properties of the modeling material, the behavior of the model underground opening will be predicted by a finite-element method. This predicted behavior will then be compared with the measured model behavior. (R. E. Heuer)

2269-6Ø036 Physics. Three-Body Decay Integral Equations. Several unstable elementary particles are known to decay into three-particle final states. The final state interactions between these three particles can have a significant effect on the amount of the total energy each one gets. Coupled integral equations have been derived which describe the effect of these interactions on the energy spectra in terms of the parameters of two-particle scattering. The computer will be used to solve these integral equations by complex number matrix approximation and subsequent matrix inversion. The energy spectra thus obtained will be studied for various two body parameters to determine the sensitivity of the spectra to these parameters. (R. L. Schult)

2270-6Ø037 T Economics. Study of Manufacturing Firms. The aim of this study is to estimate the parameters of a dynamic model of a firm's behavior that encompasses production decisions, input decisions, inventory decisions, liquidity decisions, and money capital decisions. The estimation of these parameters will be accomplished by using the method of two-stage-least-squares on data taken from the U. S. Federal Trade Commission-Securities and Exchange Commission Quarterly Financial Report for Manufacturing Corporations. (John Boie)

2271-6Ø038 Political Science. Nativity and Political Participation. This research is an attempt to determine the impact of previous political cultures on political assimilation of immigrants in the American political culture. Methods of analysis will include cross-tabulation, rank order and Pearson's correlation, analysis of variance, regression, Guttman-type scaling methods, and other statistical techniques. The data for this research are obtained from the University of Michigan presidential election studies. The data were originally collected through national survey sampling. Essentially, the computer results will be used to analyze various hypotheses about the problem under consideration. (A. H. Miller)

2272-6Ø039 T Psychology. Person Situation and Interaction in the Behavior of Hospitalized Patients. This study is a description and analysis of patient behavior as it occurs across situations in a Veterans Administration Hospital. One hundred mental patients will be observed in each of 5 situations common to all patients (such as dayroom, work detail, meals) and rated on 30 behavioral

response classes. The data will be analyzed by using Tucker's Three-Mode Factor Analysis and the analysis of variance. The basic question is to find out to what extent patient behaviors are a function of immediate environmental situations. (Larry Killian)

2273-6Ø043 T Chemistry and Chemical Engineering. Rotating Flows. Fluid flow in isothermal and non-isothermal rotating systems is being studied. Enclosed flows, which are characterized by the fact that angular momentum is transported toward as well as away from the axis of rotation, are being considered. A study is also being made of non-isothermal flows in which motion is caused by a non-uniform fluid density. Finite difference and approximate orthogonalization methods are primarily used. (J. L. Hudson)

2274-6Ø044 T Sociology. Undergraduate Orientations to Higher Education. Conceptualization of the experience of higher education is subject to considerable variation from one socio-economic sector of American society to another. The present study represents an effort to delineate the diverse orientations to higher education held by undergraduates enrolled in all departments of the University of Illinois and to specify certain sociological correlates of the various perspectives. The extent to which students favorably conceptualize the academic, political, and social aspects of the institutional environment is hypothesized to be largely derived from attitudes and expectations reinforced by familial and peer interaction prior to entrance into college. Therefore, the study is further concerned with the identification of sociologically significant variables associated with favorable and unfavorable attitudes toward various aspects of the student's experience. A questionnaire incorporating indices of the attitudes outlined above was administered to 513 undergraduates enrolled at the University of Illinois during the 1966 spring semester. Analysis of the data thus obtained will require utilization of a correlation program, a frequency count program, and a chi-square program. (Bruce H. Johnson)

2275-6∅050 Institute of Labor and Industrial Relations. Pacific Coast Ocean Borne Commodity Tonnage Aggregation. The problem consists of data reduction by summation, by commodity and port for the U.S. Pacific coast, of about 27,000 line entries in Corps of Engineers reports of goods tonnages. The output will be annual tonnages for the Pacific coast, for the eleven year period 1955-1965, by broader commodity classifications than those used by the Corps of Engineers. Data processing will reduce the approximately 2400 line entries for each year to about 50, or a total of about 550 for the eleven years. The tonnage data will be used as an input in a subsequent problem to estimate productivity and to infer characteristics of the production function for the industry. The aggregation and commodity reclassification is required in order to match the tonnage data to the man-hour and related data obtained from previous research. (Paul T. Hartman)

2276-6∅051 State Water Survey. Unconsolidated Aquifer Data Analysis. The computer will be used to assemble and analyze basic data concerning hydrologic property variation of unconsolidated aquifers in Illinois. In addition, programs will be written to study the present well construction feature and determine optimum specification for designing water wells for maximum efficiency. (Thomas Prickett)

2277-6∅052 Education. An Analysis of Census Data from Chicago School District 8. In order to obtain a social profile of Chicago School District 8, census data for the tracts within the district were obtained. The computer will be used to analyze the census data. Percentages, medians, means, modes of groupings of census tracts will calculated. SSUPAC will be used for the analysis of the data. (Bernard Spodek)

2278-6∅053 Accountancy. Preparation of Accountancy 325 Materials. This project deals with generations of random numbers by various methods, such as the multiplicative and mixed congruential methods; single and multi-channel queuing; and simulation using languages such as F∅RTRAN and DYNAM∅. This investigation is intended to determine the feasibility of having students program models, and the applicability of alternate modes of presentation for use in large section classes. Where models have been

written in languages such as SIMSCRIPT, the feasibility of converting the algorithm to FORTRAN or SCATRE will be investigated. (Uretsky)

2279-6∅054 Physics. Nuclear Structure Studies. This nuclear physics research project involves the solution of the Schrödinger equation for both bound and free nucleons in order to ascertain the degree to which nuclear models describe the observed properties of the bound states and continuum (i.e., scattering) states of nucleons. (Peter Axel)

2280-6∅055 Physics. Processing of Monochromator Data. The computer will be used to aid in processing experimental data obtained in studies of the interaction of gamma rays and nuclei. One part of the analysis involves manipulating the experimental data to extract the implied nuclear information. This includes simple data fitting procedures, normalization, and chi-square tests. The second part of the analysis involves fitting the corrected nuclear information to nuclear models, using standard chi-square tests and parameter search routines. (Peter Axel)

2281-6∅063 T Institute of Labor and Industrial Relations. Differences in Perception Within Line and Staff. The problem revolves around a questionnaire administered to fifty production foremen and fifty industrial engineers. The questionnaire consists of twelve issues each having twenty-one scales or answers. It is hoped that the computer will, through factor analysis of the semantic differential, show differences in responses between the two sample groups. The computer will also be used for multiple correlations of variables (i.e., age, length of time in company, education, etc.) with scores obtained from issues. (Ken Jennings)

2282-6∅064 T Psychology. Analysis of Quay Questionnaire Data. The purpose of this project is to analyze the data from administration of a personality questionnaire which classifies delinquent boys into three groups. The questionnaire was administered to 268 delinquent boys, and from this group 45 boys were selected to participate in a vigilance experiment. This experimental group consisted of 3 groups of 15 boys each, with each group being comprised of boys who scored high on one scale and low on the other two

scales. Differential predictions were made concerning the performance of the three groups on the vigilance task. A supplementary personality questionnaire was also administered to the boys in the experimental groups. One part of the analysis will consist of studying the questionnaire data, i.e., calculating means and standard deviations of (1) subjects' age, (2) subjects' IQ, and (3) questionnaire scales; intercorrelating the scales within each questionnaire; and correlating the scales of the two questionnaires. Analysis of the experimental data will consist primarily of analysis of variance of reaction time scores and vigilance scores, fitting of regression lines to performance curves, and correlating performance with IQ. Most of the work will be accomplished using SSUPAC programs. (J. Burdeane Orris)

2283-6Ø065 Department of Computer Science. Quantum Statistics. The aim of this research is to develop approximations for certain path integrals used in quantum statistics. One such approximation, a "superposition approximation," will be used in connection with a computation of the pair distribution function. (L. D. Fosdick)

2284-6Ø066 Materials Research Laboratory. Torsion Impact on a Cylindrical Tube. The problem is to calculate the response of a thin-walled cylindrical tube to impact torsion. The material of the tube responds both elastically and plastically. The first of these responses is described by the elastic wave equation, and the second by a non-linear strain-rate equation. Thus, the mathematical problem consists of simultaneously solving these two equations with appropriate boundary conditions. The results are intended for comparison with experiments that are in progress. (J. J. Gilman)

2285-6Ø067 Chemistry and Chemical Engineering. Spin Echo Data Processing. The computer will be used to analyze data obtained from pulsed nuclear magnetic resonance (spin-echo) studies. Chemically exchanging systems are to be studied by standard techniques in which the relaxation rate of the system is obtained as a function of pulse spacing. From such a plot other spectral parameters can also be obtained by various curve fitting techniques. In most cases approximate formulas can be combined with least square fit methods. (Terry Dean Alger)

2286-6ø068 Agricultural Engineering. Analysis of Trusses with Rigid Joints. This problem is part of a project to develop improved analysis and design of farm buildings. The specific problem to be solved is the analysis of a series of roof trusses with rigid joints. The STRESS program will be utilized to determine deflections, member forces, and moments for a series of trusses of various spans, loadings, roof slopes, and geometries. (J. O. Curtis)

2287-6ø069 Department of Computer Science. Structures. This research problem relates to the development of computer techniques for defining, manipulating, and graphically displaying three-dimensional structures. A specific problem under investigation is a folded-plate system composed of a large number of modular units, all hinged together to form a continuous movable linkage system. (Resch)

2288-6ø070 T Educational Administration. Teacher-Administrator Perception of In-Service Education. The purpose of this research is: (1) to gauge the effectiveness of in-service education in ten selected high schools, as perceived by teachers and administrators; (2) to test the hypothesis that teachers and administrators view the effectiveness of in-service education differently; (3) to provide data which might suggest a need or basis for improvement. A group of 611 teachers and administrators in ten high schools filled out a twenty-item questionnaire during their monthly faculty meetings. The statistical treatments to be used in this study include: (1) one-way analysis of variance among teacher and administrator scores in the ten schools; (2) the t-test for difference between mean responses of teachers and administrators; (3) chi-square analysis between patterns of response of new and experienced teachers. (4) The pattern (frequence) of responses for teachers and administrators in each school will also be reported. (Savage)

2289-6ø071 T Zoology. Bioenergetics of Narceus Americanus. A study of metabolism in Narceus americanus, a millipede, will be analyzed using SSUPAC's Multiple Correlation program. The metabolism was measured in the laboratory as calories consumed and assimilated at various combinations of temperature, humidity, and food moisture. The regression formula obtained will be used to

predict metabolism at values of these environmental factors which were measured under field conditions. The result will be an estimate of metabolism under natural conditions at various times during the year. (Robert O'Neill)

2290-6N001 T Electrical Engineering. Forced Oscillation in Non-Linear Sampled Data System. The objective of this problem is to investigate the possibility of predicting the properties of any type of forced oscillations in a relay-type sampled-data control system, when the input is a sinusoid with any frequency. A wide-range of inputs will be assumed, and the system response will be studied. The output will be analyzed to see whether some generalizations could be made about this class of systems. (E. F. Samara)

2291-6N002 Speech and Theatre. Speech and Language Index. SALI, Speech and Language Index, is an attempt at a typological classification for speech and language deficiencies. The scale includes two groups of tests (Speech and Language) considered of diagnostic importance as well as two groups of observations and measurements (Hearing and Other) where deviations from the "normal" would be pertinent to progress in therapy, and are identified here as prognostic information. The performances of approximately three hundred speech defective children on the individual test items will be weighted through the use of a multiple regression analysis to determine the relative importance of each item to a judgment of severity of the speech and language problem made by experienced speech pathologists. The derived weights will be used to calibrate the importance of deviations on individual tests to the severity rating and hence arrive at an objective measurement that will have both diagnostic and prognostic descriptive information and allow a measurement of the child's progress in therapy as well as an evaluation of the effectiveness of the therapist. (Harold A. Peterson)

2292-6N003 T Electrical Engineering. Bulk Recombination-Generation Noise. The problem involves the calculation of the generation-recombination noise from impurity centers in insulated-gate-field-effect-transistors. This requires a considerable amount of numerical calculations,

including numerical integration of closed integrals and numerical solutions of differential equations. The theoretical computer results will be used to check the experimentally measured data. (L. D. Yau)

2293-6N004 Electrical Engineering. Electromagnetic Boundary Value Problems. The problem arises from the solution of Maxwell's Equations for diffraction gratings and other periodic structures as well as for the waveguide-discontinuity types of problems. The method to be used involves the formulation of solutions in terms of an infinite set of equations using a function-theoretic approach. It is required to generate a function to satisfy an equation of the type

$$\left\{ f(w)/f(-w) \right\} \Big|_{w = w_n} = t_n$$

for $n = 1,2,\ldots,m$. The t_n's are known; they are ratios of infinite products. The final solution will also be expressed in terms of ratios of infinite products, which in this case will resemble the Gamma function in the asymptotic behavior. (T. Grantham)

2294-6N005 Theoretical and Applied Mechanics. Optimization of Reflector Shapes. The mathematical part of the problem involves studying the properties of the equation

$$\left| \frac{x}{a} \right|^{\alpha} \pm \left| \frac{y}{b} \right|^{\beta} = 1$$

where a, b, α, and β are positive constants which may be varied to give the desired mathematical characteristics. The equation is to be used in the design of a wave reflector. The problem is to develop reflector shapes which will produce desired wave configurations. The procedure used will be to vary the parameters in the above equation in order to determine optimum shapes for producing a given set of reflective characteristics. (W. J. Worley)

2295-6N006 T Psychology. Role Relationship Patterns. The purpose of this research is to develop a methodology to analyze role-relationship patterns. As such, it will include one or more cycles of development, administration, analysis, and revision of a questionnaire. At this time, four dimensions seem relevant; these include sets of specific behaviors, role partners, modes of perception, and respondent variables. The computer will be used in various phases of data analysis. The two major analyses planned at this stage are: (1) using SSUPAC programs to determine intercorrelations among the items in each set of variables; and (2) using a 3-mode factor analysis program to determine underlying factors within each set of variables. (M. C. Blackburn)

2296-6N007 T Zoology. Analysis of Parental Behavior of _Cichlasoma Nigrofasciatum_ (Pisces, Cichlidae). _Cichlasoma nigrofasciatum_ (Pisces, Cichlidae) is one of a number of fishes that exhibit a pattern of parental behavior called fanning. When it is fanning, the parental fish circulates water over the developing young by rhythmically beating its pectoral and caudal fins while holding a position close to the young. That circulation presumably facilitates the exchange of respiratory gases between the young and the environment. The units of fanning (beats) are digital and occur in series (bouts) of variable length but relatively constant tempo. Other behavior patterms are expressed during intervals between bouts of fanning and, in some cases, during fanning itself. Quantitative samples of the frequencies of fanning beats and other activities that occur during the course of the fanning cycle have been recorded with a multi-channel event recorder activated by a manual keyboard. The parental behavior of 29 pairs of _Cichlasoma_ has been studied. The temporal changes in fanning that occur during the three-day fanning cycle are similar for all of the animals studied. Preliminary analysis indicates, however, that the bouted structure of fanning is not independent of other behavioral events. Computer time will be utilized to assess the dependence of the several measures of fanning activity that have been recorded on the frequencies of other behavioral events, using multiple correlation analysis as a tool. Based on the results of this analysis a more complete description of the whole of the behavioral changes that occur during this phase of the reproductive behavior of _C. nigrofasciatum_ will be possible. (John C. Mertz)

2297-6N008 Education. Curriculum Evaluation Studies. The computer will be used to process data gathered from schools, curriculum projects, and innovation studies to determine relationships (correlational and inferential) between teaching methods, environmental conditions, and student learning. Conclusions will guide educators in the development of educational programs and in the selection and adoption of available programs. (Stake)

2298-6N009 Education. Teaching Techniques Laboratory Analysis. The teaching techniques laboratory has been organized to provide a relatively controlled environment for the study of teaching behavior. Two outcomes are anticipated: first, the identification and operational definitions of specific teaching behaviors, and second, the development of technologies for the production of teacher candidates skilled in the use of the identified behaviors. The central feature of the laboratory is a process known as microteaching. While the microteaching and learning is real, the complexities of classroom situation are diminished by reducing the size of the class and the length of the lesson taught. Extensive use of video-recordings is made, which serves two functions. First, the recordings provide a remarkably clear record of the microlesson, which serves as a basis for the analysis and classification of teaching behavior. Second, the same tape record is used to provide the trainee with feedback useful for the refinement of his own professional behavior. Data are obtained from panels of trained judges, often paid high school pupils, who render evaluations based on observational instruments especially developed for the project. These evaluations are averaged and classified by treatment, personality characteristics, and subject area for various statistical procedures. These data are chiefly pre/post treatment scores to be analyzed with covariance techniques. Correlational techniques will be used in instrument development. (Wm. D. Johnson)

2299-6N010 T Theoretical and Applied Mechanics. Transform Methods Applied to Transient Response of Mechanical Systems. This project is an investigation of possible advantages of numerically determining system transient response by transform methods. The primary methematical method will be calculation of transformation and inversion integrals. Some calculation of system transfer function will be necessary. Computer results will be used to check the accuracy of the method against solutions obtained by classical methods. (Clark R. Barker)

2300-6N011 T Theoretical and Applied Mechanics. Nonlinear Vibrations of a Circular Plate. The problem involves the solution of two nonlinear coupled fourth order partial differential equations. These equations will be approximately solved for the static case using a combination of series and averaging methods. The solution for the dynamic case will be attempted by averaging methods and perhaps by perturbation series methods. (Richard Bolton)

2301-6N019 T Civil Engineering. Priority Rating of Highway Improvements Based on Congestion Data. The problem is to investigate the acuity of congestion on a set of urban arterial highways and find the maximum level of congestion tolerable, before improvement is contemplated on such arterials, subject to given levels of speed, travel time, and load factors for the intersections on the route. A linear programming format will be used to find the maximum level of congestion, and to analyze the relative costs of congestion on those sections of roadway where actual congestion exceeds this computed maximum level. The data have been obtained from a 180-mile speed and delay study on the St. Louis County urban arterial system. Available data gathered in the study were: average speed, travel time, and a congestion index based on the above values. The relative costs found through the operation will be used to rank the sections of roadway in question for improvement priorities. (L. E. Haefner)

2302-6N020 T Accountancy. The Determinants of Consumers' Expenditures on Transportation. This problem is an attempt to determine which of three methods of estimation of correlation (time series, cross section, or a pooling of both methods) will yield the best results in terms of goodness of fit and predictive accuracy. This will be done by using data for private consumers' expenditures for transportation. The data will be taken from the Bureau of Labor Statistics Survey of Consumers' Expenditures for 1950 and 1960, time-series data for 1947-1964, Bureau of Labor Statistics surveys for 1936, 1940-1941, and 1943-1944, and the Life Survey of 1955. The stability of the resulting parameters will be examined between all these surveys. The model will consist of four equations, one for each category of transportation expenditure, and one for the total. The computer will also graph the relation between the dependent variable and each of the independent variables for each survey. (Abo-Baker)

2303-6N021 Mathematics. Orthogonal Latin Squares. This problem is an attempt to produce on the 7094 a triple of mutually orthogonal latin squares of order 10. The proposed general method is to start with random 10-symbol quintuples, then let the computer make improvements. The mathematical object hoped to be constructed probably does not exist. However, absolutely no progress has been made toward a non-existence proof; hence, an attempt to contruct seems justified. (E. T. Parker)

2304-6N022 Physics. Microtron and Linac Calculations. A number of calculations are to be performed within the coming year on specific phases of the new accelerator project at the Physics Research Laboratory. These calculations include ray tracing of electrons through various configurations of fixed magnetic fields and high-frequency electric fields. The purpose of the calculations is to evaluate the performance of a proposed microtron incorporating a superconducting linear accelerator. (C. S. Robinson)

2305-6N023 Chicago Circle Student Counseling Service. Test Scoring - Strong Vocational Interest Blank. The IBM 7094 will be used to score Vocational Interest Examinations for the Chicago Circle Campus. Programs and scoring techniques will be developed by the Systems Consulting Office of the University of Illinois at Urbana. (James Creaser)

2306-6N028 Geography. Statistical Analysis With Regard to Bergmann's and Allen's Rules. The computer will be used in conjunction with a SSUPAC correlation program to examine the validity of the anthropological rules of Bergmann and Allen in describing certain mammalian species. The data have been obtained from a number of published papers giving body measurements for certain mammals. The results will be used in the preparation of a term paper in the course Introduction to Human Ecology, Geography 369. (Henry B. Slotnick)

2307-6N029 Geography. U. S. Mortality Rates. The computer will be used in conjunction with a SSUPAC transformation program to collate mortality data from cards and tapes and generate rates per 100,000 living population for each state. The data have been supplied by the National Center for Health Statistics, U. S. Public Health Service, in the form of computer tapes

and published tables. The computer computations will be used to prepare maps showing the distribution of mortality (by cause of death) for each state. These maps will be published in the medical section of the U. S. National Atlas, now in preparation under the direction of the U. S. Geological Survey. (Armstrong)

2308-6N032 T Physiology. Computation of Blood Flow in Vessels and Tissue. Data from a large number of indicator dilution and depot clearance experiments will be analyzed to determine blood flow in vessels and tissue. Techniques used will be data smoothing, summation of area under a concentration-time curve, and least squares fit. An analysis of variance will be used to statistically test for differences in flow due to various experimental conditions. (Fred Downey)

2309-6N033 Agronomy. Regression of Soil Test on Phosphate Fraction. Thirty-nine samples of alluvial soils from north India have been collected. The inorganic phosphorus in these samples was fractionated into its aluminum, iron, reductant, and calcium bound forms. In addition, the available phosphorus in each sample was estimated by using the Bray, Olson, and Surface methods. The main objective of the study is to determine the relative abundance of the various forms of inorganic phosphorus and their interrelationships with the available phosphorus as measured by each of the three methods. Correlation and multiple regression techniques will be used to analyze the data. The results of the analyses will be used to aid in the selection of soils to be used in soil fertility field experiments in north India. (Tyner)

2310-6N037 T Agronomy. Nitrogen Metabolism in Wheat. The basic objective of this study is to determine if there is a relationship between the nitrate reductase enzyme in growing wheat plants and the protein content of grain produced on the plants. Such a relationship would provide a new tool in the breeding and selection of strains which could be used to increase the protein content of wheat. Since much of the wheat produced in the United States is relatively low in protein, this would be an important contribution to the world's supply of protein foods. In this study the enzyme level throughout

the growing season is being characterized for 32 wheat varieties. In addition the effects of supplemental nitrogen fertilization on enzyme level and protein in the grain, and the effects of environmental conditions (i.e., temperature and light) are also being studied. Statistical analysis of the data will be performed on the IBM 7094 using analysis of variance and correlation programs currently available. (Croy)

2311-6N039 T Physics Betatron Laboratory. Photodisintegration of He^4 by 340 MEV Bremstrahlung. The photodisintegration of helium-4 by the 340 million electron volt bremstrahlung beam of the University of Illinois betatron will be studied, with particular emphasis on two-body photodisintegrations above the pion threshold. Photodisintegration fragments will be detected by solid state and scintillator telescopes. The computer will be used to calculate efficiencies, kinematics, energy loss relations, and other parameters necessary for the effective design of the experiment. It will also be used to analyze the pulse height information from the detector telescopes for particle identification and energy determination purposes. Some of the mathematical techniques to be used are Monte Carlo calculations and numerical integration. (S. E. Kiergan)

2312-6N040 Entomology. Hypergeometric and Binomial Assessment of Contagion in Three Dimensions. A number of theoretical distributions, such as the Poisson, the negative binomial, Neyman's contagious distributions, Thomas's double Poisson, and so on, have long been available for the assessment of randomness and contagion in two dimensions. Increasingly sophisticated methods of gathering and recording field data in three dimensions, as in soil pits and in aquatic studies with suspended nets, offer possibilities for analysis for randomness in three dimensions simultaneously.

In a three-dimensioned grid, each internal intersection is the point of conjunction of eight cells. If all cells have a probability $\underline{p}$ of being occupied in some given manner, and if cells so occupied are distributed at random, the distribution of intersections representing the conjunction of 0, 1, 2, ..., 8 occupied cells is given by $(\underline{p} + \underline{q})^8$, where $\underline{q} = 1 - \underline{p}$. A structurally equivalent formula can be written for the algebraically more complex hypergeometric situation in which the probability of occupancy of successive cells decreases with successive occupancy. The standard chi-square computation permits comparison of either the binomial or the hypergeometric

expectations with observed corner-conjunction counts from experimental grids. The hypergeometric distribution approaches the binomial as its limit as grid size become infinitely large. On small grids, of a size practical in field studies, the hypergeometric and binomial expectations are sufficiently different to warrant their separate examination. Natural populations may depart from randomness either in the direction of uniformity or in that of contagion. Against the latter alternative, by far the commoner in nature, the binomial expectations provide a more conservative test.

Several factors complicate the application of corner-conjunction analysis. Cells along the periphery of a grid have corners at which fewer than eight cells are conjoined, so that the effective value of the probability p may differ considerably from its value obtained by a simple cell count if the peripheral cells are disproportionately occupied. Within the grid itself, the condition of any given cell, as occupied or unoccupied, effects the corner-conjunction counts obtained at eight intersections, so that the observations are not strictly independent of each other. The effect of this, while clearly to reduce the variance, is rendered quantitatively complex both by the peripheral cells which may contribute 1, 2, or 4 corners, and by the ratio of peripheral to internal cells which changes with overall grid size. For these reasons it has appeared unwise to assume that the chi-square obtained from the comparison of observed and expected values do necessarily have the chi-square distribution. The present IBM 7094 computer study is a "Monte Carlo" assessment of the practical consequence, if any, of these elements of inequitable corner contributions and non-independence. The study will determine whether the chi-squares obtained from 1000 randomly filled grids at each of five grid sizes do in fact have chi-square distributions appropriate to their respective degrees of freedom. (Arthur W. Ghent)

2313-6N041 Physical Education for Men and Graduate PE. The Effect of Stance Variation and Ball Position on Golfing Achievement of College Men. The purpose of this study is to determine whether or not using different methods of presenting stance and ball position to a beginning golfer would have any significant effect upon his golfing achievement at the end of a seven-week instructional period. The analysis of variance technique will be employed to test the hypothesis that there was no significant difference

between the four experimental groups at the end of the treatment period. Should a significant F value be obtained, t-tests will be run to determine where the difference(s) exist(s). It is also necessary to determine the correlation coefficient between each of the factors involved. (Richard Youngberg)

2314-6N042 T Electrical Engineering. Molecular Energy Levels and Transition Frequencies. This research is in the new area of molecular gas lasers. The overall aim is to identify the molecular transitions which are seen in laser emission. The computer will be used to compute molecular transition frequencies from known energy levels which are available in the technical literature on molecular spectroscopy. When the energy levels are known, the transition frequencies are obtained simply by subtraction of appropriate energy levels. In some cases, the data available in the literature are incomplete as to the molecular energy levels. Here the computer will be used to compute additional energy levels. This can be done using energy formulas and spectroscopic constants for the molecule of interest. (W. Q. Jeffers)

2315-6N043 Curriculum Laboratory. Analysis of Chapter Tests. It is desired to evaluate special tests for the seventh grade project of the University of Illinois Committee on School Mathematics. Eight to twelve of these tests will be given to each of approximately 2300 students in nine urban areas. The computer will be asked to give the item difficulty, the reliabilities, the means and variances of certain groups, and the correlation with the scores by student. An analysis of variance will be done also. The results will be used to justify the tests for reliability and validity. They will also show the effectiveness of a novel format for testing culturally disadvantaged children.
(J. R. Hoffmann)

2316-6N044 Agricultural Engineering. Undergraduate Thesis Research. Numerous problems of limited scope comprising research for undergraduate theses will be undertaken. An example is a problem to evaluate the increase of overall efficiency possible by automatically adjusting a variable speed internal combustion engine and a variable ratio hydrostatic transmission operating under variable speed and load conditions. (Roger Yoerger)

2317-6N045 Institute of Communications Research. Experiments in Semantic Feature Analysis. This project in psycholinguistics involves the study of dennotative meaning. A series of related experiments is in progress to determine the features, or dimensions, which underlie distinctions in word meanings. The features are derived through study of the contents within which words occur. Data are obtained primarily from subjects' semantic judgments. The analyses involve standard statistical methods, e.g., correlation and multivariate analyses. Computer results are used to test experimental hypotheses. (M. Wilkins)

2318-6N048 Physics. Three Body Kinematics. As part of a program of nuclear reaction studies at the University of Illinois Cyclotron, data from three body reactions are accumulated in a multi-channel analyzer. A kinematically selected region from analyzer output is then plotted by a CalComp plotter. In this form the data ia amenable to further analysis. The main computation concerns the selection of suitable elements from a 64 x 64 data matrix. In generating the kinematic region, numerical integrations are necessary to establish an accurate energy scale. (James S. Allen)

2319-6N049 T Chemistry and Chemical Engineering. Solution of the Navier-Stokes Equations. The object is to solve the Navier-Stokes equations for flow around submerged objects and in cavities. The computer will be used to solve the finite differences approximations of the Navier-Stokes equations. Starting with initial values obtained from an analytical solution for idealized cases, more general solutions will be obtained for different values of the problem parameters (for example, Reynolds number) by iteration. The final numerical results will be compared with data obtained experimentally in order to evaluate the method of solution. (David P. Siegwarth)

2320-6N051 T Astronomy. Atmospheric Model. The object of this research is to derive a model atmosphere for the planet Jupiter. It is hoped that a comparison between the predictions of such a model and the actual observations will give a more accurate indication of the atmospheric composition in regards to hydrogen, helium, and ammonia, and will indicate whether Jupiter has an internal heat supply or not. The problem is basically the solution of radiative transfer and convective transfer of heat energy from the lower layers to the upper layers of the atmosphere. Additionally, there are the equations of hydrostatic equilibrium, the equation of state, and the equations governing the absorption coefficient of the material. The complexity of the problem arises because the absorption coefficient is a function of frequency. Additionally, if scattering is also taken into account, the problem becomes even more difficult. The solution is to be derived through the numerical integration of the coupled differential equations. If that proves unsatisfactory, then an iterative process will modify trial solutions until one fitting the boundary conditions is found. Various initial conditions will be tried to find a model which satisfies the observations. The CalComp plotter may be used to graph the output values. (Gary Goodman)

2321-6N052 Physics Betatron Laboratory. Processing of Monochromator Data. The computer will be used to aid in processing experimental data obtained in studies of the interaction of gamma rays and nuclei. One part of the analysis involves manipulating the experimental data to extract the implied nuclear information. This includes simple data fitting procedures, normalization, and chi-square tests. The second part of the analysis involves fitting the corrected nuclear information to nuclear models, using standard chi-square tests and parameter search routines. (Peter Axel)

2322-6N053 Physics Betatron Laboratory. Nuclear Structure Studies. This nuclear physics research project involves the solution of the Schrödinger equation for both bound and free nucleons in order to ascertain the degree to which nuclear models describe the observed properties of the bound states and continuum (i.e., scattering) states of nucleons. (Peter Axel)

2323-6N054 T Zoology. Composition and Diversity of Avian Populations in Successional and Climax Plant Communities. Data collected on avian populations and vegetation composition at Allerton Park, Kickapoo State Park, and other areas will be analyzed to determine the changes in composition and diversity which occur in avian communities with successional changes in vegetation. Attempts also will be made to correlate some of these changes with accompanying changes in composition and diversity of vegetation. Thirdly, bird populations of various types of climax plant communities having relatively stable plant composition and structure, in contrast to successional stages, will be analyzed to determine if their diversity remains constant with time. Information theory will be used in calculating the indices of diversity. (James R. Karr)

2324-6N055 T Physical Education for Men and Graduate PE. Effects of Competitive and Non-Competitive Physical Activity on Cardiovascular Fitness, Stress Adaptation, and Anxiety of Men. The purpose of this study is to determine the effects of progressive, non-competitive, continuous running and calisthenics and individual sports competition on selected cardiac intervals and other cardiovascular measures, the response of these measures to sub-maximal physical exercise and mental arithmetic, manifest anxiety, and motor fitness of adult men.

Sixty men, 25 to 50 years old, were assigned to the following five groups:

A. Running and calisthenics, 3 days per week.
B. Running and calisthenics, 5 days per week.
C. Handball/Badminton, 3 days per week.
D. Handball and Badminton, 5 days per week.
E. Control Normal activity only.

The subjects will be tested prior to, during, and at the conclusion of the five month training period, November through March, on the following tests:

(1) Resting cardiovascular measures, including selected cardiac intervals and forces, using the Cameron Heartometer and simultaneously recorded carotid pulse wave, phonocardiogram, EKG (lead II), and BCG (acceleration).

(2) Response of these measures to mental arithmetic and sub-maximal physical exercise (5 minute ergometer ride, 4500 ft. lbs./min., 40 r.p.m.).

(3) Manifest anxiety (revised Taylor Scale).

(4) Motor fitness battery, including vital capacity, strength, power, agility, balance, and flexibility.

Principal components will be determined on the first and last testing periods. These components will be used in discriminate analysis using the following orthogonal comparisons of groups: (1) A + B + C + D - 4E; (2) A + B - C - D; (3) A - B + C - D. These comparisons will determine the effects of training, type of training, and amount of training respectively. (Burleigh D. Franks)

2325-6N056 T Civil Engineering. Numerical Model Study of Prestressed Concrete Structures with Openings. Distributions of stresses and strains in prestressed reinforced concrete thick shells with openings, due to the action of static and perhaps dynamic loads, are to be determined by means of numerical techniques based on an appropriate grid model. The model, now being developed, will permit the study of the effect of variations in the structural parameters, such as reinforcing, hole size and shape, etc. This study will have its most direct application in the design of containment vessels for nuclear reactors. (A. Echeverria)

2326-6N057 Civil Engineering. Block Adjustment and Auxiliary Data. This particular problem deals with the Duane Brown Block Adjustment program in analytical photogrammetry, which was received from the Air Force. The program involves the rigorous adjustment of a block of stereo aerial photographs to some given ground control using the method of successive block overrelaxation to solve large matrices which contain the coefficients of non-linear differential equations. The program is to be modified to accept camera station parameters (i.e., auxiliary data) rather than ground control for the solution of the adjustment equations. Fictitious data will be generated and perturbed in its parameters by random errors held within a predetermined standard deviation. Thus by testing a whole sequence of perturbed data it is hoped to gain an insight into the maximum random errors in the parameters which will still allow an adjustment of the block of photographs consistent with certain accuracy requirements for mapping topography from the adjusted block of photographs. (Dennis Moellman)

2327-6N058 Civil Engineering. The Continuation of Gravity Anomaly. The problem is to reduce the gravity anomalies observed by airborne instruments to the surface of the earth and study the accuracy of the reduced quantities. Theoretically, a system of linear integral equations should be solved in order to reduce the anomalies of elements surfaces downward to the system of linear integration equations. In this problem the possible matrices are ill-conditioned. The best solution was proved to be an iterative process. An efficient iterative process is developed for this problem by employing the relaxation principle. A practical and theoretical error analysis on the result of the iterative process will be conducted. Matrices will not be used at all in order to avoid any storage problems, as the number of unknowns will in general be over 400. Previous experience with similar computer programs showed that a single iteration for 360 unknowns took 5 minutes on the IBM 7094 (Ohio State University Monitor system). Four iterations, at least, are required in order to reduce the data, or study its errors, from one altitude. Data from three areas of different gravitation conditions, at three different altitudes in each area, will be studied. (M. F. Madkour)

2328-6N060 Psychology. Empirical Evaluation of the Distribution of a Markov Chain Statistic. The central limit theorem for Markov chains states that for an ergodic chain, the distribution of the number of times in a given state of the chain during the first n steps approaches the normal distribution (for limiting variance greater than zero) with estimable mean and variance as n approaches infinity, and that this is the case for any starting state of the chain. The question of interest in this investigation is how well the normal distribution approximates the observed distribution for n = 30 with a two-state chain, given that the chain is stationary (i.e., the vector of initial probabilities is the fixed vector of the chain). For each of several transition matrices, 1000 30-step random samples will be obtained using a library random number generator. A chi-square goodness-of-fit test will be used to evaluate departure from normality. Approximate normality, if found, will be used to justify the use of such a statistic in testing the significance of observed departures of performance curves from theoretical performance curves predicted on the basis of a Markov chain model of young children's behavior in various prediction and retention tasks. (R. S. Bogartz)

2329-6N061 Recreation. The Effects of Recreation Leadership on Guests of Homes for the Aged. The purpose of the study is to determine the social and physical changes that are brought about by the introduction of a recreation program into a home for the aged. The effects will be assessed by comparison between observations made at a "pre-recreation" time and observations at a "post-recreation" time. Also, in a control home in which the recreation leader is present and participates in activity (but does not initiate or lead them), observations will be made at similar times. Statistical analysis requiring the use of SSUPAC will be conducted to determine the extent to which the various differences in observations can be attributed to the treatment. Specifically, t-tests, correlation coefficients, and analysis of variance will be required. (Parker)

2330-6N062 Materials Research Laboratory. Thermal Conductivity of Solid Helium. The computer is to be used to calculate the thermal conductivity of solid helium crystals using carbon resistance thermometers. Initial electrical resistance, R, versus temperature, T, data for these resistors are derived from helium vapor pressure and helium gas bulb thermometer measurements. These data will be fit in a least squares sense to the equation

$$1/T = A + Bx + Cx^{-1} + Dx^{2} + Ex^{-2} + Fx^{3} + Gx^{-3}$$

where $x = \ln R$. From the derivative of this equation changes in temperature corresponding to small changes in R can be calculated. Knowing the temperature difference between two points on the crystal corresponding to a measured heat input into one end of the crystal, the thermal conductivity can be calculated. (William D. Seward)

2331-6N063 Educational Testing. Analysis of Time-Series Quasi-Experiments. In the social sciences and education, an experimental design which is often useful is one in which a person or group is observed and measured at several regular intervals prior to the introduction of an experimental treatment (T). Several observations are made following T. An abrupt change in the level of the average score of the group between the observation immediately prior to T and those following might indicate a causal relationship. A crucial problem in such "time-series" experiments is to determine whether or not this abrupt change should be attributed to random fluctuations or to an outside influence. Recent explication of an integrated moving average model by Box and Tiao suggests that such a model can be applied to the solution of this inference problem. The computer will be used to evaluate the modifications and adaptations of the mathematical statistician's models necessary for application to educational problems. Several examples of time series experiments taken from the literature of experimental education and psychology will be processed. (Glass)

2332-6N064 Physics. Nuclear Cross Section Calculation. The University of Illinois cyclotron is used to produce a beam of charged particles which, when scattered from target nuclei, yield an energy spectrum. These data are then accumulated in a multi-channel energy analyzer. The computer is first used to plot these spectra so as to be in a form that is easily analyzed. From basic

physical considerations, formulas for nuclear "cross-sections" can be derived. Knowing the energy spectra and the appropriate formula, nuclear cross-sections can be computed. Finally, an angular distribution plot (cross-section versus scattering angle) is obtained with the help of the computer. These enable the various nuclear energy levels to be defined, and are the basis for most spectroscopic studies. (R. A. Hoffswell)

2333-6N065 Sociology. Intellectuals and Interpersonal Influence. The computer will be used to analyze data gathered for a study of the relationship of intellectuals to interpersonal influence in public affairs within the local community. The data were gathered by means of an attitude survey in four cities. The computer will compile frequency distributions, compile percentage distributions, and calculate chi-square tests of significance. The analyzed data will eventually be part of a book on the role and nature of the intellectual in contemporary American society. (M. Dicker)

2334-6N066 T Nuclear Engineering. Analysis of Three Parameter Fission Study. The energies of the two fragments from fission of U^{235} and the K-X-rays coincident with them will be measured and recorded on magnetic tape. The data will be sorted by the computer to yield X-ray spectra for the different mass modes of fission. The masses of the two fission fragments are determined from the energy measurements by an iteration process, since the energy calibration of the detectors is dependent on the fragment mass. The X-ray spectra will be analyzed to yield information about the fission of U^{235}. (E. Bohn)

2335-6N067 Department of Computer Science. IBAL Translator. A translator from the ILLIAC III Basic Assembler Language (IBAL) to ILLIAC III machine code will be written for the IBM 7094. The translator will consist of four passes using a state transition matrix for an initial syntax check as well as an incoming symbol priority system during the production of object code. The translator will be used for the initial translation of ILLIAC III system programs. (John Schwebel)

2336-6N068 T Educational Psychology. Adolescent Values. A study has been conducted to explore the direction of adolescent decisions and the underlying values which influence their behavior. Three instruments were applied to a sample of college bound high school students and a sample of vocationally oriented high school students. Correlation coefficients and the chi-squared test will be used to determine the significance of findings. (Nadine Tooley)

2337-6N069 Civil Engineering. Headlight Glare. The computer will be used for the analysis of field headlight glare data to determine the tolerable glare levels as related to median width. Field data were collected under controlled driving situations during the summer of 1965 and 1966. An analysis of variance statistical technique will be performed on data for disability glare and (separately) on data for discomfort glare. The results of this type of analysis will indicate the significant variables in the glare problem and will aid in the development of tolerable glare figures for use in design of divided highways in the future. (Lee Webster)

2338-6N070 T Sociology. Divorce and Kinship Affiliation. Data on 82 married couples have been obtained regarding their attitudes toward divorce and their kinship affiliation. This information was obtained by administration of questionnaires. From Bernard Farber's model of family organization, the hypothesis that kinship systems can be used to predict attitudes toward divorce was derived. An index of kinship affiliation was devised as well as a means of measuring attitudes toward divorce. The computer will be asked to factor analyze the items used in measuring attitudes toward divorce and to locate the underlying factors. It will also cross tabulate the index of laterality with the attitude measuring instrument computing the statistic Gamma, a measure of association. Pearson's product-moment correlation will be run on two indexes of laterality to determine how close they are as indicators of laterality. (Charles Mindel)

2339-6D001 Astronomy. Isophotal Contours of Comets. Direct photographs of comets will be measured in a digitized microphotometer. The plate transmissions will be translated to relative intensities through plate calibration information obtained from the automatic digitizing equipment. The intensities will be plotted in the form of isophotes, using the CalComp plotter. (Kenneth Yoss)

2340-6D002 Mathematics. Diophantine Calculations. The problem of basic interest is the special case of Hilbert's Tenth Problem as applied to the diophantine equation

$$x^2 = y^3 + R.$$

Certain information about small solutions of this problem will be obtained. The procedures are mathematically trivial and the computer cannot possibly solve the problem, but it is hoped that the information obtained will be of some help in obtaining a solution. (K. Appel)

2341-6D003 T Materials Research Laboratory. Analysis of Gamma Ray Spectra. Gamma ray spectra measured by a 400 channel pulse height analyzer are read out on punched paper tape, which is then converted to punched cards. The gamma ray spectra are normalized for counting time and total number of counts, and corrected for background and gain shift. Then, up to 15 pure gamma ray spectra (i.e., containing only one radioisotope) are least squares fitted to a composite spectrum (i.e., containing more than one radioisotope) to determine the coefficients of contribution of each pure spectrum. These coefficients are directly proportional to the concentration of radioisotopes present in the composite spectrum. The CalComp plotting system is used to plot the gamma ray spectra. (W. Lussie)

2342-6D004 Civil Engineering. Analysis of the Slope Stability of a Sloping Core Dam. The problem to be solved by the computer is a slope stability problem concerned with the stability of the upstream slope of a sloping core dam. The solution to the problem is an application of force equilibrium equations. The procedure involves the assumption of a failure surface and calculation of the factor of safety for the assumed failure surface. A comparison is then made between all calculated factors of safety to find the lowest value. This value is the critical value for the section. The computer will be used to calculate the corresponding factors of safety. The results obtained will be used to draw curves which will give the lowest factor of safety. (David M. Hendron)

2343-6D005 Agricultural Economics. Special Milk Program. This project involves the study of the changes in the consumption of milk in public and private schools under the Special Milk Program. One of the objectives of this study is to attempt to determine the factors which explain the difference in the consumption of milk per student between schools. Multiple regression analysis will be the statistical tool utilized to achieve this objective. The data were obtained from the office of the Superintendent of Schools in each county. Income and percent nonwhite data were obtained from census data. The results of the regression analysis will be useful in ascertaining ways in which the use of milk in schools can be expanded. Standard program procedures for regression analysis will be utilized. (James Gruebele)

2344-6D006 T Speech and Theatre. Differential Effects of Personality Variables in Dyads. The purpose of this project is to study the effects of personality variables in two-person groups. The principal variable under consideration is belief in internal-external control, i.e., the extent to which a person believes his successes and failures are due to his own efforts, or to chance or luck. Rotter's scale for internal-external control will be correlated with the Cattell 16-Personal Factor inventory. From these correlations predictions will be made about the effects in group discussion of varying degrees of internal-external control. Finally two-person groups will be assembled according to the degree of internality-externality displayed by the subjects, and differential predictions made about the effect of the personality variable. Final results will be evaluated by analysis of variance. (W. T. Page)

2345-6D007 T Nuclear Engineering. Analytical Investigation of Liquid Metal Flows. The evaluation of analytical expressions for the transfer of heat in liquid metal flows will require the use of both circular and cylindrical functions in converging series expressions. It is expected that some data reduction will also be required as comparison for these evaluations and that both results will be plotted by the computer. (B. G. Jones)

2346-6D008 T Chemistry and Chemical Engineering. Momentum Analysis of Atomization in Two-Phase Flow. A momentum analysis of the liquid film in parallel air-liquid flow is being attempted to predict conditions under which droplets will be torn from the flowing film. This is part of a study of the forces involved in atomization. The integral momentum equation resulting from use of a shallow water assumption in the Navier-Stokes equations is tabulated. Solutions under which a shock condition in the liquid film is allowed are recorded. Mathematical methods to be used include Runge-Kutta integration, table interpolation, and polynomial-root techniques. The results will be compared with experimental observations. (D. E. Woodmansee)

2347-6D009 Civil Engineering. Dynamic Structural Response. The computer will be used in the analytical study of elastic dynamic response of a multi-story building to simulated earthquake motions. The problem solution requires a step-by-step numerical integration of the dynamic equations of motion. A set of simultaneous equations are solved at each step of the numerical integration. Depending on what information is desired, the computer program may also solve an eigenvalue problem and its associated eigenvectors. Earthquake accelogram records will provide the earthquake motions. The computer results are to be compared with experimental results of model studies as a test of the adequacy of the mathematical description of the structure used in the analytical study. (J. F. Harris)

2348-6D010 T Civil Engineering. Structural Safety to Random Excitations. The object of this study is to formulate a numerical approach for the computation of first passage probabilities of a single-degree-of-freedom system subjected to filtered shot noise excitations. The resulting two dimensional Fokker-Planck equation for the system can be solved by means of a finite-difference scheme. For this purpose, the region of the phase plane is divided into rectangular elements. The computation is continued until the asymptotic exponential behavior is approached. The data obtained can be used to plot the first passage probability density versus the number of cycles at which first passage occurs. (Hsueh-Sheng Tsao)

2349-6D011 T Special Education. Superior Women College Students. This is a study of the relations between self concept and academic motivation of superior and of average achieving college women. It attempts to determine some of the forces in each woman's life that influence her toward academic success. Research studies on talented women are scarce, and it is important that information about their self-perceived roles in the university setting be obtained. From the Colleges of Agriculture, Education, and Liberal Arts and Sciences, some 350 junior and senior women will be selected. Measures and information as to intellectual ability, academic performance, self concept, peer and faculty relations, perceptions of university environment, biographical information, and indices of academic motivation will be obtained on each woman. Appropriate statistical analyses will be made of all data collected, relying in the main on SSUPAC programs. (W. D. Simmons)

2350-6D012 Astronomy. Cosmological Models. The purpose of the calculations is to determine the values of the most important cosmological parameters for different world models. The models are defined by the values assigned to the deceleration parameter q_o and the mean density σ_o. Two of the parameters are found by integration; the others are functions of these. Eventually the tables will be compared to cosmological observations. (Rolf Stabell)

2351-6D017 Geology. Stress-Strain Calculations in Rock Deformation. An experimental study is proposed to determine the effects of confining pressure, total strain and loading rate on the deformational behavior of a limestone, a marble, and a shale subjected to triaxial compression. A cylindrical test specimen is inserted between the platens of a press. Confining pressure is applied until the specimen is deformed to the desired strain. The strain and the axial forces are recorded throughout the experiment. Specimen length, volume, stress, strain, etc., are calculated by the computer. The program corrects for elastic distortion of the apparatus, and provides true stress and specimen strain for any time n during a given test. A stress-strain curve and a normalized stress-strain curve are also plotted on the printer by the computer. (Donath)

2352-6D018 T Astronomy. Spectrophotometry of Late-Type Stars. The current problem is to find and calibrate an accurate index of the chemical composition of late-type stars. Stellar spectra are available which were obtained at both Mount Wilson and Palomar Observatories, and at K. H. Peah National Laboratory. These will be microphotometered, the output of the microphotometer being in the form of punched cards or paper tape. The paper tape can be used on ILLIAC II, or the data can be transferred to low-density magnetic tape using the CSL 1604 facility.

Using data from stars of known composition, correlations will be made with known and suspected composition indices. These will be examined statistically through the computation of regression lines and correlation coefficients, and by visual inspection of graphs produced on the CalComp plotter and on the off-line printer.

The results can be used in several areas. As an example, if the velocity distributions of stars of different chemical composition are known, information about the change in composition of stars as the galaxy formed can be compared with nucleogenesis theories. (Thomas Lutz)

2353-6D019 T Nuclear Engineering. Analysis of Turbulence Data in Two-Stream Mixing Regions. Turbulence signals from two stream mixing regions in air are recorded on FM magnetic tape and converted, with analog-to-digital facilities, to digital magnetic tape records. These data are reduced by digital (statistical) programs to give the detailed structure of the turbulence in the mixing region. These results are utilized to check existing models of transfer of momentum, energy, and mass across the region. The detailed results are also displayed by means of the CalComp plotter facility. (B. G. Jones)

2354-6D020 Agricultural Economics. Analysis of Large Illinois Hog Producers. The analysis will be concerned with the problem of identifying marketing costs in the process of marketing hogs by producers. The data were collected in 1965 from commercial Illinois hog producers. The computer will be used to summarize the collected data. Statistical methods, regression analysis and analysis of variance, will be used in the analysis. The results of the analysis will be used for classroom instruction. (Emer E. Broadbent)

2355-6D021 Geography. Parameter Testing in Certain Resource Allocations. The project under present consideration is a preliminary analysis of the major parameters of transportation and resource allocation at various levels. By intra/interregional comparisons, it is hoped that some insights into the relation of the variables may be gained in a quantitative sense. Most of the data are in the form of population statistics and cost factors taken from census reports and various business and government agencies. Computer time will be devoted mostly to standard statistical analyses leading to various forms of static, dynamic, and stochastic programming models, with the eventual aim of developing a descriptive and generic analysis of the problem. (Kammrath)

2356-6D022 T Mechanical Engineering. Hypersonic Slip Flow Past the Leading Edge of a Flat Plate. The problem of Hypersonic Flow past a sharp leading edge of a flat plate has received much attention in the last decade because of its connection with problems encountered in space flight. No theory has been developed so far; even the experimental results are in conflict. A Kinetic Theory approach is to be applied to the shock wave region, coupled with a continuum approach in the viscous boundary layer region. The two regions are merged with each other and calculation is made possible by the concept of incomplete compression in the shock region. Conservation principles in integral form are used. With some assumptions, the resulting equations are two integral equations. These two equations can be iterated upon to give the degree of compression, the shock angle, and other parameters. The results can be used to obtain the Drag and the heat transfer. (Rateb J. El-Assar)

2357-6D023 T Zoology. Quantitative Genetics in the Leopard Frog. This project is concerned with quantitative genetics, specifically concerning the leopard frog. Correlation and regression analysis and an analysis of variance will be used to determine the relationship between parents and offspring for certain quantitative characters, such as spot number, body length, head width, etc. The data consist of external anatomical measurements and counts on the parents and offspring. The computer results will be used to estimate the degree of genetic determination of the characters in question. (Donald Underhill)

2358-6D024 T Nuclear Engineering. Monte Carlo Studies of the Effects of Polarization, Electron Binding, and Coherent Scattering on Albedo and Penetration. The research will determine the effects of polarization, electron binding, and coherent scattering on gamma ray albedo and penetration. The programs will use Monte Carlo methods and will be correlated with the standard Monte Carlo method which ignores all of the above phenomena. Cross sections obtained from tables and theoretical analysis will be the primary input data. The results will show the effects of the above phenomena and will show the contribution of these phenomena to the existing large discrepancies (sometimes 35% or greater) between the standard method (ignoring these phenomena) and experimental measurements. (W. E. Vesely)

2359-6D025 T Physical Education for Men and Graduate PE. The Relationship of the AAHPER Youth Physical Fitness Test Items with Maximal Oxygen Intake and Selected Variables on Eleven Year Old Boys. The purpose of this study is to determine the relationship of the AAHPER Youth Physical Fitness Test items with maximal oxygen intake and selected variables on eleven year old boys. The seven-item AAHPER Youth Fitness Test, maximal oxygen intake test, and selected variables will be administered to fifty eleven year old boys from Champaign and Urbana. Pearson product-moment correlation coefficients will be computed among all the motor performance items and between the motor performance items and maximum oxygen intake and selected variables. An acceptable multiple correlation will be used to obtain a correlation coefficient between the motor performance items and maximum oxygen intake and selected variables. Acceptable multiple regression techniques will be used to eliminate those items which make an insignificant contribution to the estimation of maximum oxygen intake and selected variables. The computer results will be used to develop prediction equations which will predict maximum oxygen intake and selected variables from the AAHPER Youth Physical Fitness Test items. (Victor A. Corroll)

2360-6D026 T Civil Engineering. An Investigation of the Lateral Buckling of Expanded Beams. The castellated beam is assumed to behave as a vierendeel truss with center lines at centers of gravity of the flange and web sections. Equations governing stability are developed as differential equations. The investigation will study the effects of size and shape of openings on the

lateral stability of such beams compared to the solid beams. Finite difference method is used to simplify the differential equations of stability into a set of linear simultaneous equations. There will be n equations in n unknown lateral deflections and the lateral buckling load. To get the value of the lateral buckling load, the determinant of the set of equations is equated to zero. The computer is to be used to solve a set of simultaneous equations and to find the critical buckling load. The program will be modified to handle other opening shapes. (Fathy A. Morsy)

2361-6D027 Nuclear Engineering. Particle Trajectory and Turbulence Measurements. Two wire turbulence data are being examined by digital techniques to develop suitable analysis programs for regular use. Particle trajectory data are being subjected to modified analyses to improve the signal-to-noise ratio of the calculated quantities. (B. G. Jones)

2362-6D028 Agricultural Economics. Economics of Soil and Water Conservation. The net returns from alternative farm plans for typical situations in Illinois will be estimated. The alternatives considered will include various methods of soil and water conservation. Planning horizons of up to 50 years will be considered. To provide comparability between plans, net returns for each year will be discounted and summed to obtain present values. The computer will be used to calculate the present values. A successful program has been written for this calculation. Linear programming will be used to select optimal plans for each typical situation. (E. R. Swanson)

2363-6D029 Health Education. Anti-Smoking Education Study. The research problem is concerned with identifying the attitudes and practices of junior and senior high school students with regards to smoking. The project consists of three phases: (1) initial completion of the survey; (2) treatment periods; and (3) second completion of the survey. The data from the first phase will be processed (a) to obtain descriptive information about the groups and certain sub-groups; (b) to get a frequency count, so that schools can be paired for the treatment periods; (c) to see if the items on the attitude portion of the survey instrument are discriminating between smokers and non-smokers; and (d) to see how the responses on the items relate to responses on other items.

The frequency count will show the smoking behavioral patterns in the individual schools and grades. The t-test will be used as a preliminary step toward the development of a Guttman scale for selected items to be used in latter stages of the study. (W. H. Creswell)

2364-6D030 Chemistry and Chemical Engineering. Integrals for Perturbation Theory. Perturbation Theory is only now being used for the calculation of molecular wave functions. Offsetting its advantages is the difficulty of calculating the multielectronic (i.e., many-dimensional) integrals that arise. Present calculations on H_2, using Gauss quadrature, indicate that a combination of these methods with more conventional ones may make perturbation calculations practical for larger systems. Numerical quadrature methods other than Gauss will also be considered. Careful programming is important in calculations of this type to make evaluation of integrals numerically an efficient process. (Jerry Goodisman)

2365-6D031 T Theoretical and Applied Mechanics. Quantitative Dislocation Substructure. The overall project for which the computer will be used concerns a study of the dislocation substructure of metals which have been deformed by various types of loading, i.e., creep, fatigue, etc. The size of the cell structure is of interest. The mathematical methods used will be those of statistical analysis. Curve fitting is the primary goal. The data will be obtained from literature and from experiments. Information sorting and handling procedures will be used here. The results from the computer will be used to study the relationships between various loading parameters and cell sign (sub-grain size). (Brian R. Gain)

2366-6D032 T Psychology. Minnesota Multiphasic Personality Inventory Content-Configural Analysis. Thirteen raw clinical scale scores obtained for approximately six hundred subjects on the Minnesota Multiphasic Personality Inventory will be transformed into T-scale scores and then sorted by computer into eight different levels of configural analysis. The degree of homogeneity within configurations in terms of thirteen content scale scores will be investigated for all levels by means of analysis of variance. Content scale means and standard deviations for the various configural levels will also be required. (Payne)

2367-6D033 Anthropology. Application of Statistical Techniques to Model Testing. This is a study of a genetic population simulation using a model of genic action based on the recent DNA research, rather than the "population genetics" approach. Individual bits will be used to simulate bases on a DNA string, and a program simulating physiological development will lead to the production of a phenotype. At this stage, the effects of selection upon the phenotype can be simulated at the DNA level, and mutation at the DNA level can be seen at the phenotypic level. Several evolutionary hypotheses will be tested when the system is debugged, including the effects of relaxed election. (M. Wolpoff)

2368-6D035 T Political Science. Secondary Mobilization of the Farm-Oriented Vote. This problem is part of an investigation into the political aspects of PL 480 (the Food for Peace program). To test hypotheses about the deterioration in farm political power, examination will be made of the social bases of political support for farmers among the non-farm population. Data source will be the election surveys made by the University of Michigan Survey Research Center in 1952, 1956, 1960, and 1964. Analysis of the data will involve correlation and regression analysis. Computer results will be used to test a series of related hypotheses, covering 52 different variables. (William Anderson)

2369-6D036 T Mechanical Engineering. Thermal Contact Resistance. To predict the heat flow between two solids, it is necessary to determine the area of contact. The contact elasticity problem will be formulated in terms of finite differences. The resulting linear algebraic equations will then be solved. (R. O. McNary)

2370-6D037 T Psychology. Dimensional Analysis of Manual Expression. The present study is an attempt to discover the underlying dimensions of manual emotional expression. To do this, the experimenter had 78 subjects rate 36 photographs of hands on 40 7-point bipolar scales of emotional expression. The data will be analyzed by means of a three-mode factor analysis, a recently developed technique (subjects by pictures by scales). This analysis will aid the experimenter in naming the appropriate relevant dimensions of manual emotional expression as well as in indicating the characteristics of manual expressions that elicit specific scale judgments. (Gitin)

2371-6D038 Psychology. The Objective Measurement of Motivational Structure. Fifteen years of research, covered in some thirty publications, on the objective measurement and factor analytic structuring of human attitudes and interests, have yielded a coherent model and body of knowledge tentatively named the dynamic calculus. The aim of the present research is to subject certain constructs and hypotheses derived from the model to more complete experimental checks and to develop, in greater detail, the model and methods for examining its statistical fit. Specific aims of the study are as follows: (1) to examine further the validity of objective motivation measurement devices; (2) to gain a more complete perspective on human dynamic structures; (3) to examine hypotheses about influences on human drive tension levels and sentiment development levels by entering on manipulative and selective experiments. In each of these areas, the use of the computer is necessary for the efficient handling of such large volumes of data as a study of this magnitude is likely to produce. Specifically, the application of factor analytic statistical methods, which provide the model and primary manipulations for the present study, requires the use of a large, fast and efficient computer such as that offered by the present installation. (R. B. Cattell)

2372-6D039 T Mechanical Engineering. Machine Tool Structures and Costs. The problem deals with the relationship between the machine tool structure and its cost. The deflections and weights of different configurations of structures will be determined using developed formulas. A relationship between the calculated deflection and weight values, and cost figures obtained from a machine tool company, will be sought. Thus, a series of figures of merit, expressing the relationship deflection/cost will be developed for a series of basic structures of machine tools. These figures of merit will facilitate and systematize the managerial decision making function of a machine tool company. (Isaac Moked)

2373-6D040 Library Science. Library Statistics and State Agencies: A Comparative Study. A study of the role of the state library agency in the compilation and publication of library statistics is being sponsored by the State Libraries of Illinois, Indiana and Missouri. As part of this evaluation the use of published library statistics by public library administrators is

also being analyzed. The analysis of use will be based on responses to a checklist distributed to a systematically selected sample of 411 public libraries in the three states. The responses will be tabulated to provide frequency counts by state and by size-of-library for 41 different sources and categories of statistical information. In addition, certain measures of association will be described using chi-square to test for statistical significance. (Guy Garrison)

2374-6D041 State Geological Survey. Mineral Matter in Coal. This is part of a detailed research project concerned with mineral matter in coal and its effect on air pollution. Size analyses of coal, mineral matter from coal, and fly ash obtained from the combustion of the same coal in a powder fuel-fired boiler will be done on a wide variety of samples. The size analyses will be done on a "Coulter Counter" and the raw data taken manually. This instrument gives a measure of the volume of particles which have equivalent spherical diameters of one-half to several hundred microns. These pulses must then be translated into volume and then to size fraction to be meaningful. The data following reduction by computer can be further analyzed to determine affects of size analyses of mineral matter and coal on air pollutants derived from the coal. (H. Gluskoter)

2375-6D042 T Materials Research Laboratory. Electron-Ion Potential. The overall project is a study of the relationship between electron-ion potentials, dielectric function, and phonon frequencies in sodium and potassium. Inelastic neutron scattering experiments provide the dispersion curves relating phonon frequency and wave vector in these metals. A knowledge of the dielectric function is sufficient to compute the desired potential by a least squares fitting procedure. The degree to which a given dielectric function provides a fit to all available data will test the approximations used in reducing the general expressions to simple form suitable for quantitative solution. (W. R. Fehlner)

2376-6D043 Speech and Theatre. Illinois Children's Language Assessment Test. The study concerns itself with the administration and standardization of an instrument that has been adapted from the Schuell Short Examination for Aphasia. This examination utilizes items which test areas that appear of

importance in the evaluation of adults with language difficulties and applies them to the testing of pre-school children. The instrument, which is being standardized on a population of approximately 150 youngsters with no known language difficulties, will later be administered to a population of youngsters with auditory disturbances, visual disturbances, speech and language disturbances, and writing difficulties. The computer will be used in item analysis which will be conducted in terms of individual test items and individual subjects in terms of sex, age, and verbal IQ. (Phyllis Arlt)

2377-6D044 Linguistics. Automated Phonology. Linguistic theory at its present stage distinguishes a phonological component as part of the grammatical apparatus needed to explain the linguistic competence of speakers of natural languages. This component consists of rules which operate upon segments, hypothetical linear units of language which bear the ultimate distinctive information in the form of a small number of binary distinctive features. The rules are of two types - one of very limited generative capacity which can change the specification of a segment according to the phonological context, and a second of vastly greater power which can, in addition, add or delete segments according to context.

In order to test this model, linguists often write sets of rules corresponding to data gained from the study of actual languages. Unfortunately, the time involved in the methodical application of even relatively few rules to relatively few forms practically precludes detailed investigations in this area. It is therefore proposed to construct a computer program by means of which the linguist could have his proposed rules swiftly and accurately checked. (J. M. Sadock)

2378-6D045 T Nuclear Engineering. Plasma Interactions and Emissions. A mathematical model is formulated to predict the interactions in and emissions from a plasma at high density and temperature. A two-dimensional snow-plow model will treat motion in a theta pinch. Neutron heating and deuteron fusion probability upon slowing down will be calculated. Spectral emission will be plotted. The effect of magnetic containment will be estimated. Mathematical methods to be used include fitting a curve to cross section data, numerical integration, and numerical solution of the equations of motion using finite difference techniques. The data will be obtained from cross section

references, lab measurements, fission yield curves, and spectroscopy tables. The results will be used to predict the feasibility of neutron heating, to optimize theta pinch geometry, and to estimate the effect of a strong magnetic field upon containment and interactions. The spectral emissions estimated will be compared to experimental results. Fusion reaction rates will also be compared with experimental data if predictions show that the reaction rate is significant. (Tom Dolan)

2379-6D046 State Water Survey. Basic Rainfall Totals Analysis. Statistical processing and analyses of precipitation data from four concentrated raingage networks will be performed as the first step in several applied research problems. These research problems deal with the design of hydraulic structures, weather modification, and agricultural applications of meteorological data. Data from the networks will be tabulated in the required form, mapped, and various statistical parameters calculated by the computer in conjunction with the above research applications. (Floyd Huff)

2380-6D047 Materials Research Laboratory. Absorption Coefficient in Semiconductors. Electroabsorption in semiconductors is being investigated by means of the modulation of the electric field in the space charge region of a p-n junction. Light modulation results in photon energies close to the energic gaps of the semiconductor. Measurement of the modulated light yields the dependence of the absorption coefficient on the electric field. Theoretical expressions for the absorption coefficient under the influence of an electric field are available, involving Airy functions, for which computer programs with nine significant figure accuracy have been prepared. Least square fitting of theory and experiment may give accurate values of some band structure parameters. (Paul Handler)

2381-6D048 T Educational Administration. Satisfaction with Social Interaction of Physically Disabled Students. This study is concerned with aspects of social relationships of selected students who are physically disabled. The major independent variables of the study are degree of functional disability and level of self-esteem. These variables will be investigated in relation to satisfaction with social relationships, reference groups used as a means of self-appraisal, and a variety of background

information factors. The study will also compare students who are disabled with a random sample of students who are non-disabled in relation to the satisfaction variable as well as to some areas of personal data information. Data were obtained from disabled students who met specified criteria and who agreed to participate in the study by taking psychological tests that required approximately two hours to complete. Data on non-disabled students were obtained by means of sending out questionnaires to a sample of randomly selected students living in three residence halls. The major mathematical methods to be employed are correlational techniques, the t-test for differences between means, and possibly, two-way analysis of variance. The computer results will be used to determine if there is a statistically significant difference between two disability groups, two groups formed on the basis of self-esteem and other groups that will be formed on the basis of other major variables associated with the study. (Marilyn A. Dunn)

2382-6D049 T Mining, Metallurgy, and Petroleum Engineering. Stress Analysis of Geological Features. A stress analysis of several geological features subject to a tectonic force field will be made together with an investigation of hypothetical fault planes on the basis of Anderson's theory of faulting. The theory of linear elasticity will serve as the basis of the analysis. The computer will be used to solve the field equations of this theory numerically. In the two-dimensional problems the biharmonic equation will be solved by relaxation methods; in the case of three-dimensional problems the "finite element" method will be used. (Hans Pulpan)

2383-6D050 Psychology. Social and Psychological Aspects of Stress. The problem is the development of a broad research program to explore the social-psychological sources and effects of stress. To supplement general theorizing and conceptualizing previous research in the area needs to be examined. Specifically, the variables in previous studies and relationships among them will be obtained by a literature search. These variables and relationships will be integrated into a general classification system. The computer will be used to compile the data, obtain frequency distributions, profile comparisons, reanalyze data, etc. Most analyses will require the SSUPAC programs. (J. E. McGrath)

2384-6D051 T Chemistry and Chemical Engineering. Solution of the Two Dimensional Mass Transport Equation. The problem of flow around a cylinder is being studied experimentally by an electrochemical method in which a reaction is occurring at the surface of an electrode. In order to correlate the magnitude of the reaction in the flow field around a cylinder, one has to solve the mass transport equation for this particular geometry. The computer will be used to try to solve this equation numerically and also to evaluate other approximate solutions available in the literature. (Harry Dimopoulos)

2385-6D052 Mechanical Engineering. Heating System Recovery Factors. It is often necessary to select heating equipment which will raise the air temperature within a building a specified number of degrees in a given period of time. However, engineers have very little information on which to base such a selection. The differential equations expressing the relationship between required heating system capacity and the thermal characteristics of the building and heating system are too complicated to solve manually, but by making finite-difference heat transfer calculations it is believed that practical relationships between the required heating system capacity and thermal characteristics of the building and heating system can be established. (W. S. Harris)

2386-6D053 Materials Research Laboratory. Paramagnetic Relaxation. This is a solid state research program which investigates spin-phonon interactions at low temperatures and the techniques of dynamic nuclear polarization both by the "solid effect" and spin refrigerator techniques. These phenomena depend upon the nature of spin-lattice relaxation times with respect to temperature, magnetic field amplitude, magnetic field direction, hyperfine interactions, and phonon bottlenecks. A series of FORTRAN programs has been written to: compute the angular variation of the theoretical spin-lattice relaxation times of rare earth ions in salts of suitable symmetry; fit experimental relaxation data in a least squares sense to the theoretically expected temperature dependence; and analyze raw data to extract the relaxation rates. All data are obtained by means of electron spin resonance-pulse saturation techniques in the temperature region from $0.3^{\circ}K$ to $4.2^{\circ}K$. (H. J. Stapleton)

2387-6D054 Agricultural Economics. Enterprise Selection for a Poultry Farm Supply Firm. This project has three main purposes. One is to program the enterprise alternatives of a complex yet relatively small agricultural supply firm to determine the maximum profit combination. Linear programming will be used to determine the most profitable enterprise combination both in the long and the short run. The computer will be used to calculate the linear programming solution.

The second purpose of the research is to present the findings of the study to the management of the case study firm and to develop teaching procedures and devices that will cause the firm's management to understand the model and its implications for possible future adjustments. In short, the purpose is to cause the firm management to consider alternatives and to make investment decisions on these alternatives based on linear programming research.

The third objective of the research is to develop generalized teaching material to be used with other agriculturally related business firms. These materials will show how maximum profit combinations of enterprises can be determined, what information is needed and how it can be obtained and what the solutions mean, once they are computed.

The University computer will be used only in phase one of the project. (R. P. Bentz)

8.2 Instructional Problem Specifications

During the fourth quarter of 1966, 6 instructional problem specifications were submitted to the Department for computation. The following brief discriptions of these problems have been prepared for inclusion in this report by those submitting them.

I476-6∅005 Electrical Engineering 272. Circuit Schematic Drawing. This problem involves writing an efficient program to produce schematic drawings via the IBM 7094-CalComp plotter system. The program will be divided into two parts: (1) read and check input data for errors, and (2) if there are no errors in data input, use various drawing subroutines to produce the requested schematic. In the first part, the major function of the system is to perform a series of "IF" tests on the input data. In the drawing subroutines, pen movements are calculated, making as much use as possible of symmetry in the components. The program in its present form is written in IBM FORTRAN IV for the IBSYS monitor. Some time will be necessary to rewrite the program in FORTRAN II. (A. W. Dipert)

I493-6∅041 Aeronautical and Astronautical Engineering 221. Multicell Torsion Tube. The shear stresses in a multicell torsion tube may be found from a set of simultaneous equations. (The torsion tube represents a modern aircraft wing cross-section.) The library routine "SNV1" is used to solve this set of simultaneous equations. The method is similar to those used in the aircraft industry. (C. F. Vail)

I502-6∅058 Zoology 210. Computer Generated Fly Experiment for Elementary Genetics. Computer simulation of evolving populations are to be used in a basic genetics course. Each student in a section is to receive his own population which differs from that of other students since the random number generator is used. The size of the population, the selection coefficients, and the population structure will be varied for different students. (Paul Tenczar)

I515-6N024 Ceramic Engineering 311. Indexing X-ray Diffraction Patterns With a Computer. Two specific problems will be handled with the computer: (1) A Nelson-Riley extrapolation will be made of X-ray powder diffraction data from a cubic compound. The CalComp plotter will be used to graphically plot out the extrapolated lattice parameter. (2) A Hesse-Lipson analysis will be made of the X-ray diffraction data from several orthorhombic crystals. The computer will be used to establish the lattice parameters of the crystals and to index the lines on the diffraction patterns. (V. Tennery)

I516-6N025 Geography 370. Multiple Correlation Exercise. This problem is the end of a class project designed to introduce students to data processing methods and equipment and the procedures of using SSUPAC and the Illinois computing facility. A SSUPAC multiple correlation program will be used to solve a problem involving geographic analysis of data. (Armstrong)

I525-6N046 Chemistry and Chemical Engineering 370. Multicomponent Vapor-Liquid Equilibrium. A realistic problem in multicomponent vapor-liquid equilibrium is to be given in the undergraduate chemical engineering thermodynamics course. This assignment serves not only to show the utility of computers for engineering design, but also to draw together a large part of the course. The specific problem is to find the equilibrium temperature and equilibrium vapor compositions for a multicomponent mixture as a function of system pressure and liquid composition. Nonidealities in the vapor phase are to be calculated from the virial equation of state and nonidealities in the liquid phase are to be found from a two-suffix Margules equation for the excess Gibbs energy. Specific calculations will be made for a ternary cryogenic system at elevated pressures. (C. A. Eckert)

8.3 Blanket Class Problem Specifications

During the fourth quarter of 1966, 56 problem specifications were submitted to cover all assigned problems in the following courses:

J473-6∅001 Physics 303.

J474-6∅002 General Engineering 231.

J475-6∅003 Chemistry and Chemical Engineering 341.

J477-6∅010 Civil Engineering 264.

J478-6∅011 Civil Engineering 497.

J479-6∅012 Mechanical Engineering 406.

J480-6∅016 Physics 342.

J481-6∅017 Chicago Circle Physics 392.

J482-6∅018 Mechanical Engineering 186.

J483-6∅019 Aeronautical and Astronautical Engineering 262.

J484-6∅020 Electrical Engineering 330.

J485-6∅021 General Engineering 242.

J486-6∅022 Chicago Circle Department of Materials Engineering 393.

J487-6∅023 Industrial Engineering 286.

J488-6∅024 Psychology 390.

J489-6ø025	Department of Computer Science 400.
J490-6ø026	Theoretical and Applied Mechanics 431.
J491-6ø029	Aeronautical and Astronautical Engineering 241.
J492-6ø040	Mechanical Engineering 409.
J494-6ø042	Mechanical Engineering 995.
J495-6ø045	Electrical Engineering 250.
J496-6ø046	Graduate School of Business Administration 544.
J497-6ø047	Civil Engineering 366.
J498-6ø048	Theoretical and Applied Mechanics 293.
J499-6ø049	Physics 341.
J500-6ø056	Agricultural Engineering 311.
J501-6ø057	Physics 472.
J503-6ø059	Anthropology 450.
J504-6ø060	General Engineering 232.
J505-6ø061	Mechanical Engineering 445.
J506-6ø062	Mechanical Engineering 438.
J507-6ø072	Mechanical Engineering 342.

J508-6N012	Psychology 493.
J509-6N013	Electrical Engineering 251.
J510-6N014	Electrical Engineering 296.
J511-6N015	Department of Computer Science 457.
J512-6N016	Electrical Engineering 250.
J513-6N017	Mechanical Engineering 259.
J514-6N018	Physics 490.
J517-6N026	Agricultural Economics 441.
J518-6N027	Physics 371.
J519-6N030	Chemistry and Chemical Engineering 355.
J520-6N031	Chemistry and Chemical Engineering 355.
J521-6N034	Electrical Engineering 454.
J522-6N035	Chemistry and Chemical Engineering 466.
J523-6N036	Chemistry and Chemical Engineering 373.
J524-6N038	Political Science 451.
J526-6N047	City Planning 337.
J527-6N050	Physics 480.
J528-6N059	Department of Computer Science 397.

J529-6D013	Industrial Engineering 355.
J530-6D014	Civil Engineering 473.
J531-6D015	Electrical Engineering 386.
J532-6D016	Theoretical and Applied Mechanics 392.
J533-6D034	Mechanical Engineering 306.
J534-6D055	Civil Engineering 316.

9. SWITCHING THEORY AND LOGICAL DESIGN

A new logical design procedure by integer linear programming was proposed by S. Muroga in 1965. The idea started with the design of threshold elements, but it is applicable to practically any sort of logic elements such as NAND or NOR elements. In conventional switching theory no efficient design procedure under fan-ins and fan-outs restrictions which are very important practical restrictions has been known except for exhaustive methods. Our design procedure can easily take care of fan-ins and fan-outs restrictions, by expressing them as inequalities. Anyway it is an interesting result of threshold logic which looks very useful in the conventional switching theory or practical logical design.

C. Baugh, F. Chen, S. Muroga, and T. Tsuoboi started to work this design automation problem to design networks of very few logic elements as a preliminary study of the design procedure in order to see how fast the procedure terminates. The design problem may be divided into three cases, networks with general threshold elements, networks with special types of threshold elements and networks with NOR or (NAND). The last case is most important for the current computer technology. We used Gomory's algorithms. So far we have devised few algorithms to speed up convergence and to eliminate initial inequalities. F. Chen is planning to compare the speeds of IBM 7094 and ILLIAC II based on this design automation problem.

A report on enumeration of all threshold functions of 8 variables is under preparation, adding few theorems.

T. Slivinski who started his Ph.D. thesis obtained interesting theoretical results on pseudo threshold functions. Some basic results known in threshold logic are extended into the pseudo threshold function case.

S. Muroga

10. GENERAL LABORATORY INFORMATION

10.1 Personnel

The number of people associated with the Laboratory in various capacities is given in the following table:

	Full-time	Part-time	Full-time Equivalent
Faculty	15	2	16.0
Visiting Faculty	4	0	4.0
Research Associates	1	0	1.0
Graduate Research Assistants	4	77	42.0
Graduate Teaching Assistants	0	1	.5
Professional Personnel	14	1	14.5
Administrative and Clerical	19	2	20.0
Nonacademic Personnel (Monthly)	67	3	68.5
Nonacademic Personnel (Hourly)	1	89	36.0
TOTAL	125	175	202.5

The Computer Advisory Committee consists of Professor J. R. Pasta, Head of the Department; Professor J. N. Snyder, Associate Head of the Department; Professors L. D. Fosdick, H. G. Friedman, C. W. Gear, D. B. Gillies, D. J. Kuck, B. H. McCormick, S. Muroga, T. A. Murrell, J. Nievergelt, W. J. Poppelbaum, S. R. Ray, J. E. Robertson, and D. L. Slotnick.

10.2 Bibliography

During the fourth quarter the following publications were issued by the Laboratory.

File Numbers

(1) Bond, William D., "A User's Guide to a Program which Generates Wiring Lists," File No. 718, October 31, 1966.

(2) Carter, Clifford E., "Engineering Open House 1966," File No. 718, November 2, 1966.

(3) Gear, C. W., "Numerical Solution of Ordinary Differential Equations at a Remote Terminal," File No. 716, October 1966.

(4) Kato, Masao, "Hardware Design Problems for Preliminary Specifications of ILLIAC IV. II. Instruction Sequence Control (1)," File No. 715, October 6, 1966.

(5) Kato, Masao, "A Large Scale Parallel Processing Logic Simulation System," File No. 717, October 17, 1966.

(6) Wenta, J. V., "Ampex Magnetic Tape System for ILLIAC III," File No. 720, December 5, 1966.

(7) Wenta, J. V., "Ampex Magnetic Tape System for ILLIAC III Tape Stations and Transport Mechanisms," File No. 721, December 5, 1966.

Report Numbers

(1) Gear, C. W., "Time Sharing at Illinois: Experience and Plans," Report No. 217, December 5, 1966.

Specification Numbers

(1) Casasent, D. P., "Specifications for High Voltage D.C. Supply," File No. 550-86, October 7, 1966.

(2) Casasent, D. P., "Specifications for Electron Gun Supply and Video High Voltage Isolation Amplifier, File No. 550-87, October 7, 1966.

(3) Esch, John W., "Specifications for Fixed Voltage Power Supplies," File No. 550-88, November 17, 1966.

10.3 Colloquia

"Molecular Dynamics Results on Solids, Liquids, and Melting," by Dr. Berni Alder, Lawrence Radiation Laboratory, Livermore, California, October 3, 1966.

"SABRE," by Mr. R. Parker, American Airlines - SABRE, White Plains, New York, October 10 and October 19, 1966.

"The SLAC SPECTRE Data Acquisition and Analysis System," by Professor Richard Brown, Department of Computer Science, University of Illinois, Urbana, Illinois, October 24, 1966.

"Computer Memories," by Dr. J. Rajchman, RCA Laboratories, Princeton, New Jersey, October 31, 1966.

"Recent Studies in Machine Learning," by Dr. Arthur Samuel, Department of Computer Science, Stanford University, Stanford, California, November 14 and November 15, 1966.

"Organization of Hybrid Computers," by Mr. Tom Hagan, Adage, Incorporated, Boston, Massachusetts, November 21, 1966.

"Superconductivity and Computer Memories," by Dr. V. L. Newhouse, General Electric Research Laboratory, Schenectady, New York, December 5, 1966.

"Computer Design Language," by Professor Yaohan Chu, University of Maryland, College Park, Maryland, December 12, 1966.

"The Synthesis Procedure of Asynchronous Circuits," by Professor Hiroshi Noguchi, University of Illinois, Urbana, Illinois, December 19, 1966.

10.4 Drafting

During the fourth quarter, a total of 423 drawings were processed by both drafting sections:

	General and ILLIAC II	Pattern Recognition
Large Drawings	19	7
Medium Drawings	32	109
Small Drawings	74	2
Layouts	2	72
Report Drawings	0	2
Changes	13	67
Miscellaneous	4	16
Semiconductor Coding	0	4
TOTAL	144	279

(L. A. Prendergast, J. Otten, and M. Goebél)

10.5 Shops' Production

Fabrication Facility Annual Printed Wiring Board Production Report as follows:

Facility	AEC 1018	AEC 1834	Other
Work requests processed, complete	561	435	18
Boards wired	3,593	866	0
Board conversions	411	154	0
Board repairs	56	47	0
Transistors wired	50,621	3,617	0
Diodes wired	226,223	8,847	0

Frank P. Serio

10.6 DCS Library

A computer program to keep track of what books are checked out and by whom was completed by L. Fosdick and M. Coane. Check-out slips inserted in books will be replaced by IBM cards in order to let this system work at the earliest possible chance.

Many erroneously prepared and unprepared index cards were correctly made. C. McGuire is catching up the routine work.

Since part of the new building section will be occupied by our library, the floor plan and selection of furniture have been studied.

It was decided that reports (previously called pamphlets) will be classified by either author's names, institutes' names or subjects, although reports are classified by subjects (e.g. time sharing and programming manuals) only when requested. Reports under different classifications will be cross-referenced in index cards.

S. Muroga